03M09B42

PACIFIC MEASUREMENTS
LOG/LIN AC DIGITAL VOLTMETER
MODEL 1010

INSTRUCTION MANUAL

PACIFIC MEASUREMENTS
LOG/LIN AC DIGITAL VOLTMETER
MODEL 1010

Copyright 1968 by Pacific Measurements Incorporated

The information contained in this booklet is intended for the operation and maintenance of Pacific Measurements equipment and is not to be used otherwise or reproduced without the written consent of Pacific Measurements Incorporated.

Pacific Measurements Incorporated

940 Industrial Avenue, Palo Alto, California 94303

(415) 328-0300

TABLE OF CONTENTS

Page Number

Section 1 GENERAL INFORMATION

1.1 The Pacific Measurements Model 1010 Log/Lin AC Digital Voltmeter. 1-1
1.2 Model 1010 Performance Specifications 1-1

Section 2 INITIAL INSTRUCTIONS

2.1 Receiving Inspection 2-1
2.2 Power Requirements 2-1
2.3 Chassis Grounding 2-1
2.4 Returning the Instrument 2-1
2.5 Accessories 2-1
2.6 Certification 2-1
2.7 Warranty and Assistance 2-1

Section 3 OPERATION

3.1 Front Panel Controls 3-1
3.2 Rear Panel Controls 3-1
3.3 Front Panel Indicators 3-1
3.4 Front Panel Connectors 3-1
3.5 Rear Panel Connectors. 3-1
3.6 Operating Procedure 3-2

Section 4 PERFORMANCE CHECKS

4.1 Equipment Required 4-1
4.2 Initial Turn-on 4-1
4.3 Input Accuracy Check. 4-1
4.4 Linearity Check 4-1
4.5 DMB Check 4-1
4.6 DB-Expand Check 4-1
4.7 Output Voltage Check 4-1
4.8 Frequency Response Check 4-1

Section 5 APPLICATION INFORMATION

5.1 General. 5-1
5.2 Use of Digital Display. 5-1
5.3 Use With An Oscilloscope or Recorder 5-1
5.4 Grounding. 5-2

Section 6 CIRCUIT DESCRIPTION

6.1 General. 6-1
6.2 AC to DC Converter 6-1
6.3 Log/Lin Amplifier. 6-2
6.4 Digital Display. 6-3

Section 7 MAINTENANCE

7.1 Periodic Maintenance 7-1
7.2 Internal Adjustments and Test Points 7-1
7.3 Calibration 7-2
7.4 Trouble Shooting 7-3
7.5 Parts Replacement 7-4

Section 8 SCHEMATIC DIAGRAMS

Section 9 REPLACEABLE PARTS LIST

Section 10 MANUAL CORRECTIONS

PACIFIC MEASUREMENTS INCORPORATED

SUPPLEMENTARY DATA

MODEL 1010 SPEC. 5051

This instrument has been modified to provide a 1 mw reference impedance of 1000 Ω (DBV) in place of 600 Ω.

SPECIFICATIONS

The amplitude range for 1000 Ω (DBV) impedance is -70 to +26 dBm. The other specifications remain as shown in Table 1-1.

noted 5/10/71 R.W. LaRue

MODIFICATIONS

1. The front panel marking has been modified to provide a 1000 Ω (DBV) position for the dBm 1 MW REFERENCE switch.

2. Resistor A4R155 has been changed to 287 KΩ (PM Part No. 10015-85)

noted 5/10/71

3. Make the following corrections to the manual text:

PARAGRAPH	CHANGE
3.1g	600 Ω to 1000 Ω
3.6.2.1	600 Ω (775 mV) to 1000 Ω (1.000V)
3.6.2.1c	600 Ω to 1000 Ω
4.5	0.7746 to 1.0000
	600 Ω to 1000 Ω
7.3.2s	600 Ω to 1000 Ω
7.3.2x	0.775 to 1.000

noted 5/10/71 R.W. LaRue

Not Updated

SUPPLEMENTARY DATA
MODEL 1009 OPTION 03
(MODEL 1010 OPTION 01)

This instrument is equipped with additional circuitry that provides the digital display information in BCD form at a rear panel connector. This circuitry allows the instrument to be used with most digital printers, integrated circuit logic families and computers. The following signals appear on a 24 pin connector:

1. Thirteen lines of numerical data supplied in a BCD 8421 code; 0.001 through 1.000.
2. One line polarity information.
3. One line print command.
4. Lower reference level.
5. Upper reference level.
6. Common.

SPECIFICATIONS

Logic Output: BCD, polarity and print command may be either positive or negative true.
Lower Level: Adjustable from -10V to +8V.
Upper Level: Adjustable from -8V to +10V.
Must be at least 2V more positive than the lower level.

Current Output vs Logic Level: See Figure 1

Print Command: Will supply at least a 4.5 V ac coupled positive going pulse into 1500 ohms at a rate of >1 V/μsec.

Reference Output:
Upper Level: 0.5V more negative than upper logic level.
Lower Level: 0.5V more positive than lower logic level.

OPERATION

As is always the case when interconnecting two or more measuring instruments monitoring small DC signals, care must be taken to avoid ground currents. If the input to the equipment receiving the BCD signal is isolated from ground, be sure to connect all signal leads and the common. If on the other hand the equipment has its input tied internally to ground, it is best to leave the common lead unconnected and allow the ground to be made through the third wire of the power cord.

Logic levels may be adjusted by setting the lower logic reference level to be 0.5V above the lower logic level desired and then setting the upper reference level 0.5V below the upper logic level desired. Logic can be either positive or negative true. If positive true is desired, connect the leads from the terminals on the digital display PC board, assembly A2, to the corresponding input terminals on the interface PC board, assembly 10916, marked with a "+". The terminals marked "-" must be connected to the 1.1V reference line with the jumpers provided. For negative true output, reverse the connections.

MODIFICATION

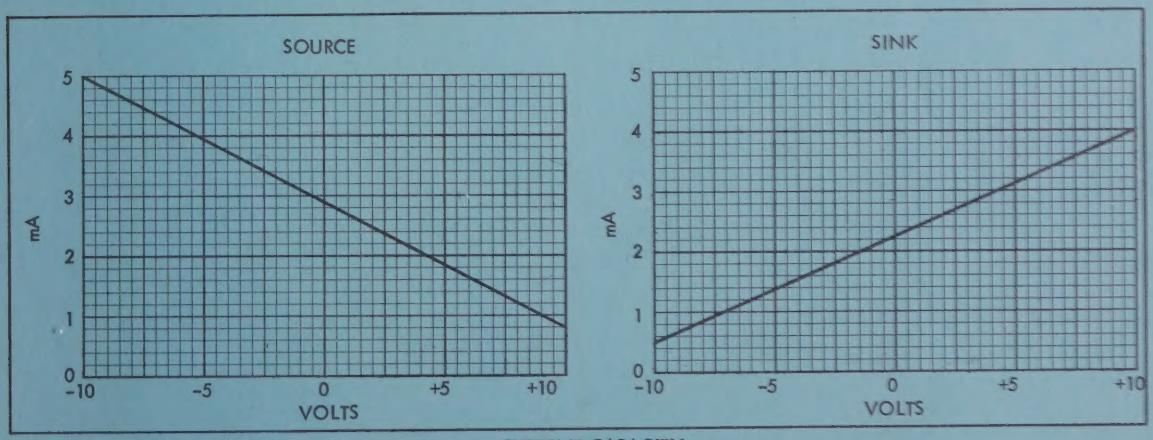
The following modifications have been made to the standard instrument.

1. A 24 pin connector has been added to the rear panel.
2. Interface PC board assembly 10916 has been added above the digital display PC assembly A2.

ACCESSORIES

The following accessory is provided with this option:

Qty.	Part No.	Description
1	10757	24 pin cable connector Amphenol #57-30240



CURRENT CAPACITY

FIGURE 1

CIRCUIT REFERENCE	PART NO.	DESCRIPTION
		REPLACEABLE PARTS LIST
C1	10000-10	Ceramic 0.1 µF +80-20% 100 VDC
C2	10000-10	Ceramic 0.1 µF +80-20% 100 VDC
C3	10000-10	Ceramic 0.1 µF +80-20% 100 VDC
C4	10000-10	Ceramic 0.1 µF +80-20% 100 VDC
CR1	10043	1N914A
CR2	10043	1N914A
CR3	10043	1N914A
CR4	10043	1N914A
CR5	10043	1N914A
CR6	10043	1N914A
CR7	10043	1N914A
CR8	10043	1N914A
CR9	10043	1N914A
CR10	10043	1N914A
CR11	10043	1N914A
CR12	10043	1N914A
CR13	10043	1N914A
CR14	10043	1N914A
CR15	10043	1N914A
CR16	10043	1N914A
CR17	10043	1N914A
CR18	10043	1N914A
CR19	10043	1N914A
CR20	10043	1N914A
CR21	10043	1N914A
CR22	10043	1N914A
CR23	10043	1N914A
CR24	10043	1N914A
CR25	10043	1N914A
CR26	10043	1N914A
CR27	10043	1N914A
CR28	10043	1N914A
CR29	10043	1N914A
CR30	10043	1N914A
J1	10758	Connector, 24 Pin Amphenol #57-40240
P1	10757	Connector, 24 Pin Amphenol #57-30240
Q1	10019	2N3565
Q2	10019	2N3565
Q3	10023	2N3644
Q4	10019	2N3565
Q5	10019	2N3565
Q6	10023	2N3644
Q7	10019	2N3565
Q8	10019	2N3565
Q9	10023	2N3644
Q10	10019	2N3565
Q11	10019	2N3565
Q12	10023	2N3644
Q13	10019	2N3565
Q14	10019	2N3565
Q15	10023	2N3644
Q16	10019	2N3565
Q17	10019	2N3565
Q18	10023	2N3644
Q19	10019	2N3565
Q20	10019	2N3565
Q21	10023	2N3644
Q22	10019	2N3565
Q23	10019	2N3565
Q24	10023	2N3644
Q25	10019	2N3565
Q26	10019	2N3565
Q27	10023	2N3644
Q28	10019	2N3565
Q29	10019	2N3565
Q30	10023	2N3644
Q31	10019	2N3565
Q32	10019	2N3565
Q33	10023	2N3644
Q34	10019	2N3565
Q35	10019	2N3565
Q36	10023	2N3644
Q37	10019	2N3565
Q38	10019	2N3565
Q39	10023	2N3644
Q40	10019	2N3565
Q41	10019	2N3565
Q42	10023	2N3644
Q43	10019	2N3565
Q44	10019	2N3565
Q45	10023	2N3644
Q46	10206	2N3053
Q47	10023	2N3644
Q48	10927	2N4037
R1	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R2	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R3	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R4	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R5	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R6	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R7	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R8	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R9	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R10	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R11	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R12	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R13	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R14	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R15	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R16	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R17	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R18	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R19	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R20	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R21	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R22	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R23	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R24	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R25	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R26	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R27	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R28	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R29	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R30	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R31	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R32	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R33	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R34	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R35	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R36	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R37	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R38	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R39	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R40	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R41	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R42	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R43	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R44	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R45	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W

CIRCUIT REFERENCE	(PR) PART NO.	DESCRIPTION	CIRCUIT REFERENCE	(PR) PART NO.	DESCRIPTION
R46	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W	R56	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R47	10013-15	Carbon Film 150 Ω ± 5% 1/4 W	R57	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W
R48	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W	R58	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
R49	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W	R59	10013-15	Carbon Film 150 Ω ± 5% 1/4 W
R50	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W	R60	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R51	10013-15	Carbon Film 150 Ω ± 5% 1/4 W	R61	10046-8	Variable 10 KΩ ± 5% 1/4 W
R52	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W	R62	10046-8	Variable 10 KΩ ± 5% 1/4 W
R53	10013-27	Carbon Film 1.5 KΩ ± 5% 1/4 W	R63	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
R54	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W	R64	10013-21	Carbon Film 470 Ω ± 5% 1/4 W
R55	10013-15	Carbon Film 150 Ω ± 5% 1/4 W	R65	10013-29	CARBON FILM 2.2K Ω ± 5% 1/4W

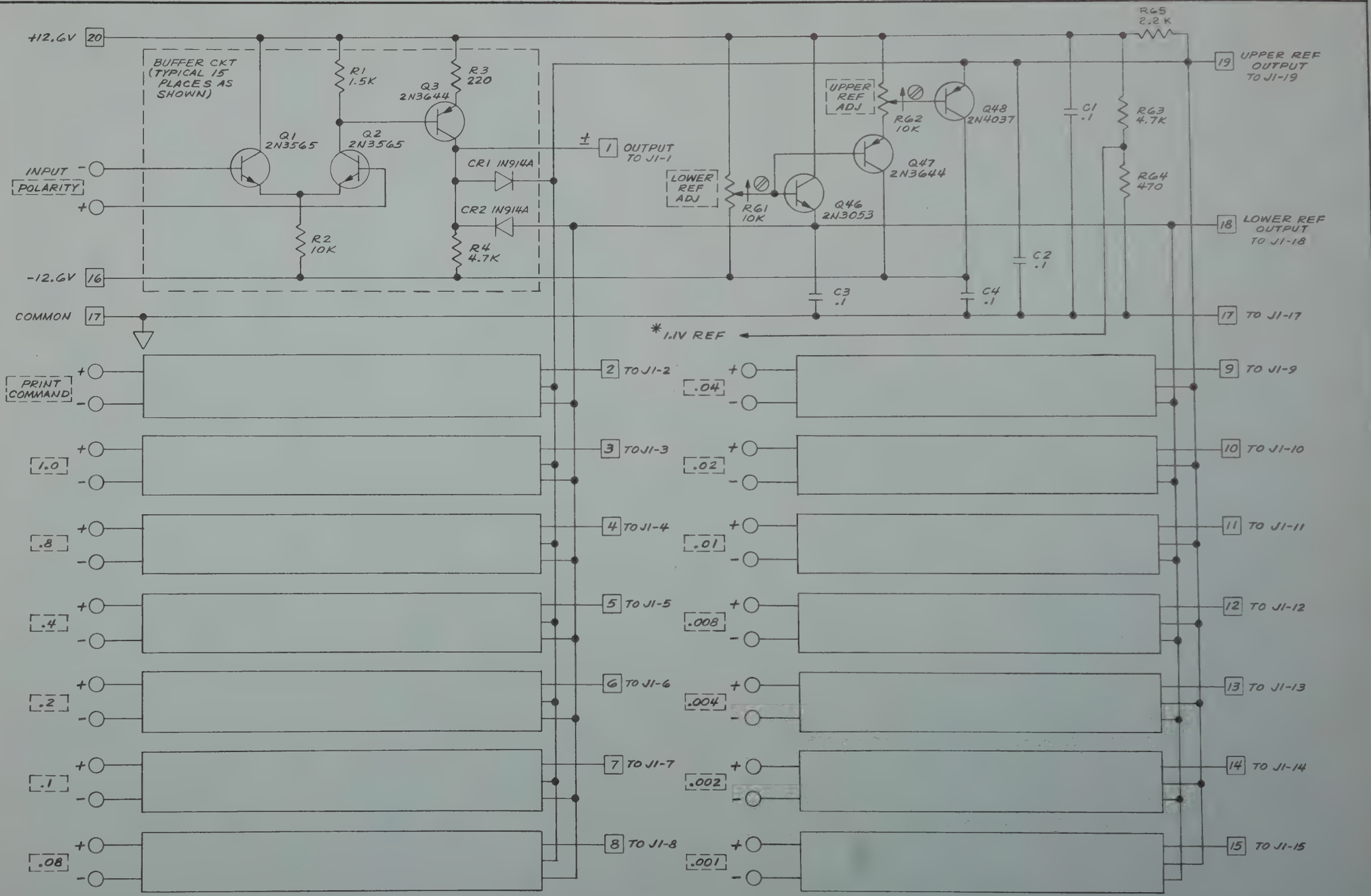
FUNCTION	OUTPUT CONNECTOR PIN NO.
Polarity	1
Print Command	2
1.0	3
.8	4
.4	5
.2	6
.1	7
.08	8
.04	9
.02	10
.01	11
.008	12
.004	13
.002	14
.001	15
Not Used	16
Common	17
Lower Ref	18
Upper Ref	19

INSTRUMENT SERIAL NO. 208

LOGIC LEVELS

ONE +5 VOLTS

ZERO 0 VOLTS



NOTES

1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.
2. * CONNECT 1.1V REF TO ALL UNUSED INPUTS.

PACIFIC MEASUREMENTS		
SCALE:	APPROVED BY: Howard Anderson	DRAWN BY YO
DATE: 2-16-68		REVISED
BCD BUFFER DRIVE		
		DRAWING NUMBER 10917

17X88 PRINTED ON NO. 1080N CLEARPRINT

SECTION 1

GENERAL INFORMATION

1.1 PACIFIC MEASUREMENTS MODEL 1010 LOG/LIN AC DIGITAL VOLTMETER.

The Pacific Measurements Model 1010 Log/Lin AC Digital Voltmeter provides a digital display of ac signal level over a wide frequency and amplitude range either linearly or in dB.

It has the unique capability of displaying the signal level directly in dBm, dB relative to an arbitrary reference, and dB on an expanded scale which permits resolution of 0.01 dB. Its frequency response is not limited by conventional feedback type ac to dc converters; instead, it employs MOS-FET's as demodulators. The instrument has a frequency response of 10 Hz to 5 MHz with a 96 dB dynamic range. It will measure in either the linear or dB mode, voltages ranging from 300 μV rms, to 20 V rms. In addition, the Model 1010 provides an analog output permitting response plotting directly in dB using an oscilloscope or X-Y plotter. In the linear mode, the output is useful for observing modulation envelopes on an oscilloscope. The Model 1010 uses average detection, which is not seriously affected by waveform distortions up to a few percent, to generate a dc voltage precisely proportional to the input ac voltage. This dc voltage is amplified, either linearly or logarithmically, to drive the digital display and analog output. Its basic accuracy at low frequencies is 0.5% and is still quite good at 5 MHz. Detailed specifications are given in Table 1-1.

A selectable filter permits the user to obtain the fastest response consistent with the frequency of the input voltage. Output impedance is low enough to permit the instrument to be used with oscilloscopes or X-Y plotters. The input impedance is similar to that found on typical oscilloscope inputs, thus permitting the instrument to be used with standard oscilloscope accessory input probes.

1.2 MODEL 1010 PERFORMANCE SPECIFICATIONS.

See Table 1-1.

TABLE 1-1

Frequency Range:	10Hz to 5MHz	
Amplitude Range:	300μV to 20V ~~(-68 dBm to +28 dBm for 600Ω impedance.)~~ -70 dBV to +26 dBV for 1MΩ impedance	
Input:	1MΩ ± 1% shunted by 40 pF; BNC Female Connector.	
Readout:	3 digits plus 100% overrange, in-line digital display	
Display Rate:		
Internal:	10 readings/second	
External:	0 to 1000 readings/second	
Trigger Input:	A minimum of +3V lasting at least 5 microseconds is required to trigger the display. Trigger input must fall below +0.5V to reset the display for a following trigger. Input impedance is approximately 50KΩ. Maximum input ±100V peak.	
Operating Modes:		
Linear:	10mV, 100mV, 1V, and 10V Full Scale	
Logarithmic:	DBM (DBV)	Absolute, (reference: 1mW into ~~600Ω~~ 1000Ω or 1mW into 50Ω)
	DB	Relative, (adjustable reference)
	DB-EXP	Relative, (.01 dB resolution)
	DB-NULL	Relative, (DVM reads magnitude of NULL offset).
Accuracy:		
(± 1 LSD)		
Linear:	100Hz to 100KHz	0.5% of reading ± 30μ V
	30Hz to 100Hz	1% of reading ± 30μ V
	* 100KHz to 1MHz	1% of reading ± 100μ V
	** 1MHz to 5MHz	3% of reading ± 1mV
	* 1mV to 20V ** 10mV to 20V	
DB Relative:	See Figure 1-1	
DBM	Same as DB Relative plus ± .2 dB @ 22°C Temp. Coef <.02 dB/°C	
Analog Output:	Female BNC Connector, Impedance < 1Ω, 1MA Max.	
Linear Scale:	1 Volt ± 1% F.S.	
Log Decibel Scale:	100mV/dB ± .25%	
Ratio Input:	Rear panel BNC, 100mV/dB ± .25% Impedance 30KΩ	

(Continued)

TABLE 1-1 (Cont.)

+59°F to +131°F

Temperature Range:	Specifications apply +15°C to +55°C (except as noted)
Power Requirements:	115/230V ± 10% 50–400Hz, 25VA
Physical:	Modular style cabinet for bench mounting
Size:	3.65" H x 16.75" W x 13.00" D
Color:	Blue with contrasting light blue panel
Weight:	15.5 lbs. (7kg.) Shipping Weight 25 lbs. (11kg.)
Option 01:	
Rear Panel BCD Output:	Provides 4 line 8-4-2-1 BCD code for numerals, polarity signal and print command. Compatible with most printers and computers.
Rack Adapter Model 1011:	For rack mounting Model 1010.

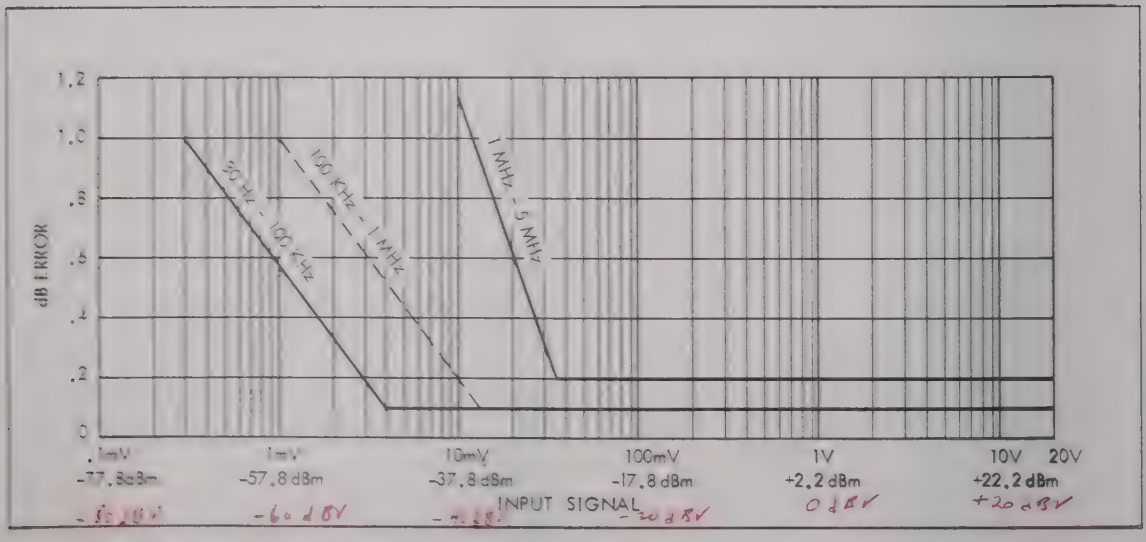


FIGURE 1-1

SECTION 2

INITIAL INSTRUCTIONS

2.1 RECEIVING INSPECTION.

Unpack the instrument carefully and check for any obvious shipment damage. If damage is evident, file a claim against the carrier. The carrier will normally supply appropriate forms.

2.2 POWER REQUIREMENTS.

Units are ordinarily connected at the factory for operation from 105 volts to 125 volts ac at 50 to 400 Hz. Units may be ordered for operation from 210 volts to 250 volts ac if so specified. Conversion from one voltage to the other may be readily made, see Figure 2-1. Reverse the Line Voltage Plate at the rear of the instrument to indicate the voltage for which the unit is wired.

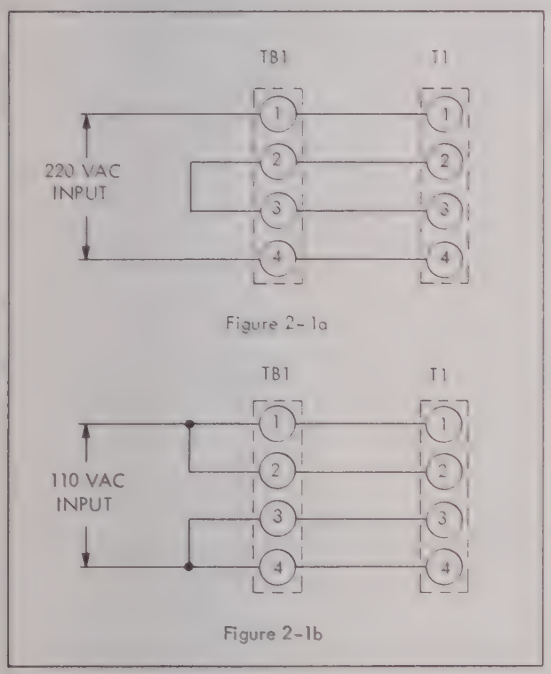


Figure 2-1a

Figure 2-1b

FIGURE 2-1

2.3 CHASSIS GROUNDING.

The instrument is supplied with a three-conductor NEMA type power cord. The instrument will be properly grounded if the plug is connected into a properly installed three-prong receptacle. If a three-prong to two-prong adapter is used, be sure that the pigtail lead of the adapter is grounded.

WARNING

FAILURE TO PROPERLY GROUND THE INSTRUMENT CAN ALLOW DANGEROUS VOLTAGES TO BUILD UP ON THE CHASSIS WHICH COULD BECOME DANGEROUS TO OPERATING PERSONNEL.

The outer conductors of the INPUT jack, AC OUTPUT jack and RATIO INPUT jack are not internally grounded to the chassis when the INPUT GROUNDING switch is in the EXT position in order that the signal ground may be isolated from the power line ground. Thus, if a high voltage is applied to this isolated ground, the outer shells of these connectors may be elevated to a dangerous potential. Care must be taken to insure that signal leads are properly grounded. Refer to Section 5.4.

2.4 RETURNING THE INSTRUMENT.

If it is necessary to return the instrument to Pacific Measurements, authorization must first be obtained from our Sales Department or local representative. Before packaging, the instrument should be wrapped in a protective material such as polyethylene to protect it from marring. If you do not have the original shipping container, wrap the instrument in a large quantity of protective padding material such as foam or hair flex and use a rugged cardboard or wooden container as a packing carton. Pack the instrument firmly so that it will not move around in the container. A letter containing all pertinent information should be included with the package unless you have already sent such a letter to our Sales Department.

2.5 ACCESSORIES.

The following accessories are provided with each instrument:

Qty.	Part No.	Description
1	10053	3 Conductor Power Cord
1	--	Instruction Manual

2.6 CERTIFICATION

Pacific Measurements Incorporated certifies that this instrument was thoroughly tested and inspected and found to meet all its published specifications when it was shipped from the factory. Pacific Measurements Incorporated further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

2.7 WARRANTY AND ASSISTANCE

All Pacific Measurements products are warranted against defects in materials and workmanship. This warranty applies for one year from date of delivery, or, in the case of certain major components listed in the instruction manual, for the specified period. Pacific Measurements Incorporated will repair or replace products which prove to be defective during the warranty period free of charge. No other warranty is expressed or implied. We are not liable for consequential damages.

For assistance contact your nearest Pacific Measurements franchised representative office or the factory in Palo Alto, California.

SECTION 3

OPERATION

3.1 FRONT PANEL CONTROLS.

In addition to the power switch, there is a row of push buttons for selecting the range and function of the instrument, a row of push buttons which must be selected in accordance with the frequency of the input signal, an offset selector, an offset control, and a display filter switch.

a. INSTRUMENT RANGE AND FUNCTION SELECTOR. This set of push buttons has the dual purpose of selecting both the range and the function of the Model 1010. The buttons concerned with linear operation select full scale sensitivity for the digital display; there are four ranges from 10 mV full scale to 10 V full scale. A decimal point and an annunciator on the display are actuated in accordance with the button selected. The buttons concerned with logarithmic operation cause the instrument to read directly in dB (decibels). When the DBM button is depressed, the instrument reads voltage relative to that required for 1 milliwatt into ~~600~~ 1000 ohms or 50 ohms depending upon the impedance that is selected. When the DB button is depressed, the instrument reads voltage relative to an arbitrary reference set by the front panel controls. In the DB-EXP mode, the instrument reads the difference between the reference set in the DB mode and an adjustable offset, with ten times scale expansion. In the DB-NULL mode, the instrument reads the magnitude of the offset furnished by the OFFSET control.

b. MINIMUM FREQUENCY SELECTOR. This control is concerned with conditions at the INPUT connector. The minimum frequency push buttons select various filters in the instrument and a selection must be made based upon the input frequency and desired response characteristics.

c. OFFSET SELECTOR LEVER. This lever permits the OFFSET knob to be used to set either an arbitrary reference value in the DB or DB-EXP mode of operation, or to adjust an offset signal which may be measured in the DB-NULL mode of operation.

d. OFFSET CONTROL KNOB. This control is used to adjust reference and offset voltages as described in Section 3.1c.

e. DISPLAY FILTER SWITCH. This switch connects a filter between the input of the digital display and the rest of the instrument to permit stable displays of noisy signals, at the expense of less rapid display response.

f. ZERO ADJUSTMENT. This screwdriver adjustment is used to set the digital display to indicate 0.00 mV when the input is shorted.

g. DBM 1 MW REFERENCE SWITCH. This switch is used to select the reference impedance for dBm measurements to be either 50Ω or ~~600~~ 1000 Ω.

h. INPUT GROUNDING SWITCH. This slide switch has two positions, INT (internal) and EXT (external). When the switch is in the INT position the outer conductors of the INPUT jack, RATIO INPUT jack and AC OUTPUT jack are connected to the power line ground. When the switch is in the EXT position these outer conductors are floating.

3.2 REAR PANEL CONTROL.

a. DISPLAY TRIGGER SWITCH. This two-position slide switch selects the source of the display trigger. In the INT position the display is triggered by an internal 10 Hz source. In the EXT position the display is triggered by a source connected to the rear panel DISPLAY TRIGGER external INPUT jack.

3.3 FRONT PANEL INDICATORS.

a. OVER RANGE LIGHT. When lit in the linear operating modes, it indicates that the voltage measuring circuitry is overloaded and that the reading is no longer accurate. When lit in the logarithmic mode, it indicates that the input signal has exceeded 20 volts and that the reading is no longer accurate.

b. DIGITAL DISPLAY. Display tubes are used to indicate polarity and three digits plus one over-range digit. The measurement units are indicated directly to the right of the numerical display. The units are mV, V, DB, and DBM.

3.4 FRONT PANEL CONNECTORS.

The shells of the front panel connectors are isolated from the power line ground. Refer to Section 2.3 for information regarding grounding the instrument.

a. INPUT JACK. This BNC jack accepts the input AC signal to be applied to the unit. Its input impedance is 1M ohm shunted by 40 pF. The maximum input signal is 20 volts AC.

CAUTION

UNDER NO CIRCUMSTANCES APPLY MORE THAN 500 VDC. EXCESSIVE VOLTAGE WILL DAMAGE INTERNAL COMPONENTS.

b. OUTPUT JACK. The output of this BNC jack is +1V for a full scale reading in the linear mode. In the logarithmic mode, its output level is 10 DB/V. Output impedance is <1 ohm.

CAUTION

NEVER APPLY A VOLTAGE TO THE OUTPUT CONNECTOR AS THIS MAY DAMAGE OR DESTROY THE SENSITIVE CIRCUITS WITHIN THE INSTRUMENT.

3.5 REAR PANEL CONNECTORS.

The shells of the rear panel connectors are isolated from the power line ground. Refer to Section 2.3 for information regarding grounding the instrument.

a. OUTPUT JACK. This BNC jack is connected in parallel with the front panel BNC OUTPUT jack.

b. RATIO INPUT JACK. This BNC jack may be used to inject a signal into the Model 1010 output for ratioing purposes. Input sensitivity is 100 mV/dB and input impedance is approximately 30K ohm. This sensitivity and input resistance allows two Model 1010 units to be used together for ratioing two signals without the need for any adjustments. A positive going signal in

this input causes a negative going output signal. This input jack is active only in the DB, DB-EXP and DB-NULL modes.

c. DISPLAY TRIGGER EXTERNAL INPUT JACK. This BNC input is used for triggering the digital display by an external source when the DISPLAY TRIGGER switch is in the EXT position. The display may be triggered at any rate from 0 to 1000 readings/second. A +3 V signal lasting for at least 5 microseconds is required to trigger the display. Trigger input must fall below +0.5 V to reset the display for a following trigger. Input impedance is approximately 50 K ohm.

d. AC OUTPUT JACK. This BNC jack provides a sine wave the same frequency and approximately the same amplitude as the input signal for use in synchronizing other equipment. Output impedance is approximately 1 KΩ.

3.6 OPERATING PROCEDURE.

a. Connect the line cord. Be sure that it is properly grounded.

b. Set the rear panel DISPLAY TRIGGER switch to get the desired digital display rate. If the display rate is to be triggered by an external source, make sure the trigger input is at least +3 V, 5 microseconds wide, and falls below 0.5 V during each cycle.

c. Turn the POWER switch to ON. The digital display should light immediately.

d. After a fifteen minute warmup, depress the 10 MV button and check that the digital display indicates 0.00 mV with the input disconnected and the INPUT GROUNDING switch in the INT position. If it does not, set the digital display to read 0.00 mV using the ZERO adjustment.

3.6.1 LINEAR OPERATION. When any of the buttons controlling the linear operation of the Model 1010 (10 MV, 100 MV, 1 V, 10 V) are depressed, the instrument will operate as a standard ac digital voltmeter.

When operating with a low level input (less than 10 MV) or when measuring a noisy signal, the last digit or two of the display may appear unstable. In order to smooth out the variations of the signal and achieve a stable display, a noise filter has been included in the instrument. With the DISPLAY FILTER switch in the IN position, the low pass filter will stabilize the display. If stabilization is not required, the filter may be switched to the OUT position and the display will respond instantaneously to input signal changes.

In order to provide the optimum response speed consistent with adequate signal filtering, a selection of three filters is made available. These filters are controlled by the MINIMUM FREQUENCY push buttons. When operating below 100 Hz, it is necessary to use the 10 Hz filter. This filter has approximately 1 second response time, so that there will be a noticeable lag in the response of the display. When operating above 100 Hz, the 100 Hz filter may be used and the response of the display will be virtually instantaneous. In addition, a 100 kHz filter is provided to permit the analog output to rapidly follow input signal amplitude changes for frequencies above 100 kHz. Thus, audio frequency modulation of a carrier frequency may be directly observed by means of an oscilloscope connected to the OUTPUT jack of the Model 1010.

The OFFSET control is disabled when operating in the linear mode.

To make a measurement in the linear mode proceed as follows:

a. Depress the appropriate MINIMUM FREQUENCY button for the signal to be measured.

b. Select the linear full scale range by depressing the appropriate button.

c. Apply the signal to be measured to the INPUT jack. Be sure it is properly grounded. Refer to Section 5.4 for information concerning grounding.

d. Select the appropriate DISPLAY FILTER position, either IN or OUT, and read the input signal level on the digital display. The lighted annunciator following the digital display indicates the correct units, either millivolts or volts.

3.6.2 LOGARITHMIC OPERATION. When any of the buttons controlling the logarithmic mode of operation are depressed (DBM, DB, DB-EXP, DB-NULL), the instrument will be responsive to input signal voltage on a dB scale. The lighted annunciator following the digital display indicates the correct units, either dB or dBm. The range of the instrument is 96 dB (i.e., a range of 66,000 to 1 or 300 microV to 20 V).

3.6.2.1 DBM MODE. In the DBM mode the instrument will display the input signal level in dB relative to a level which will supply 1 mW of power into ~~600~~ 1000 ohms (~~775~~ mV) or 1 mW of power into 50 ohms (224 mV) depending upon the position of the DBM 1 MW REF switch.

The OFFSET control is disabled in the DBM mode.

To make measurements in the DBM mode proceed as follows:

a. Depress the appropriate MINIMUM FREQUENCY button for the signal to be measured.

b. Depress the DBM button.

c. Select the proper reference impedance, either 50 Ω or ~~600~~ 1000 Ω, with the DBM 1 MW REF switch.

d. Apply the signal to be measured to the INPUT jack. Be sure that it is properly grounded. Refer to Section 5.4 for information concerning grounding.

e. Select the appropriate DISPLAY FILTER position, either IN or OUT, and read the input signal level in dBm on the digital display.

3.6.2.2 DB MODE. In this mode the instrument indicates the input signal level in dB relative to an arbitrary reference. The reference may be adjusted using the OFFSET control.

To make relative power measurements in the DB mode proceed as follows:

a. Depress the appropriate MINIMUM FREQUENCY button for the signal to be measured.

b. Apply a signal of reference magnitude to the INPUT jack. (The source of the reference signal need not be calibrated; it may be measured and set using the Model 1010 in the linear mode.)

c. Move the OFFSET selector lever to the REF position and adjust the OFFSET control until the digital display indicates 00.0 DB.

d. Move the OFFSET selector lever to the NULL position, movement of the OFFSET control knob will not

disturb the reference setting.

e. Disconnect the reference signal and apply the signal to be measured to the INPUT jack.

f. Select the appropriate DISPLAY FILTER position, either IN or OUT. The digital display now indicates the input signal level in dB relative to the reference level.

3.6.2.3 DB-EXPAND MODE. To add to the instrument's versatility, a DB-EXP mode is provided. The DB-EXP mode permits resolution to 0.01 dB on the digital display. This, however, limits the display range to ± 19.99 dB. In order to use the display, an on-scale reading must be obtained. This may be done as follows:

a. Set the digital display to indicate 00.0 at a reference level about which scale expansion is desired as described in Section 3.6.2.2 a through c.

b. Depress the DB-EXP button, move the OFFSET selector lever to the EXP position and adjust the OFFSET control knob to provide a reading of 0.00 DB on the digital display.

c. Disconnect the reference signal and apply the signal to be measured to the INPUT jack. Variations in the signal level from the reference level will now be indicated on the digital display to a resolution of 0.01 dB.

3.6.2.4 DB-NULL MODE. The DB-NULL mode is used in conjunction with a sweeping signal source and an oscilloscope and is particularly useful for examining frequency response.

In this mode the digital display indicates the offset voltage rather than the voltage on the OUTPUT jack.

To make measurements in the DB-NULL mode proceed as follows:

a. Set the digital display to indicate 00.0 DB at a reference signal level as described in Section 3.6.2.2 a through c.

b. Adjust the oscilloscope vertical position controls for zero deflection (trace in the center of the screen) with the input to the oscilloscope disconnected or grounded.

c. Connect the oscilloscope input to the OUTPUT jack of the Model 1010.

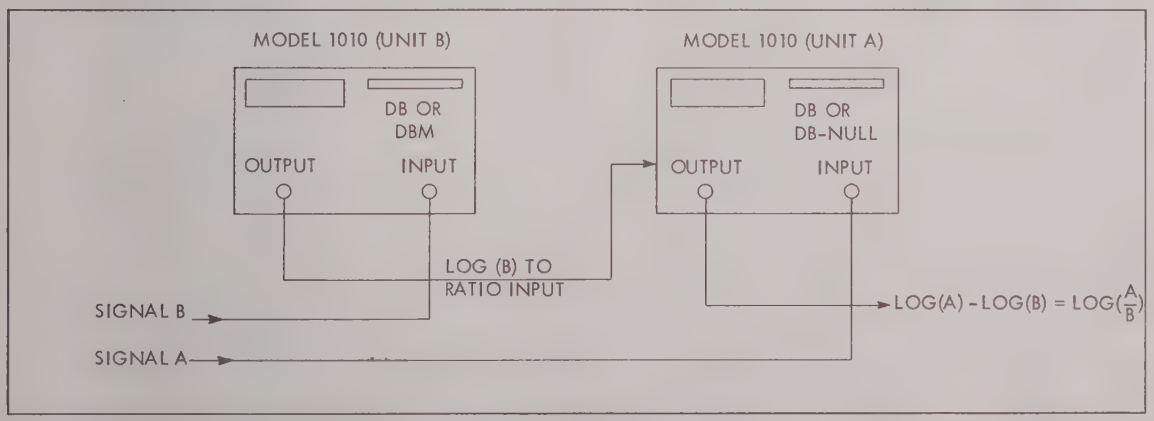
d. Connect the sweeping signal source to the INPUT jack of the Model 1010.

e. Deviations from the reference level are plotted directly in dB on the oscilloscope. The output signal from the Model 1010 is 10 dB/volt so that 1 volt/division oscilloscope input sensitivity setting will correspond to 10 dB/division on the oscilloscope graticule. Any desired scale expansion or contraction may be obtained by increasing or decreasing the oscilloscope sensitivity setting.

In the DB-NULL mode the OFFSET control will now move the trace up and down on the oscilloscope screen. Thus, any portion of the response curve may be examined at high sensitivity while still obtaining an on-screen display. In this mode the digital display will read directly the magnitude of the offset applied. That is, the center of the oscilloscope screen will be effectively offset from the reference level by the amount indicated on the digital display. Fine grain variations may be read directly from the oscilloscope display while the average level of the signal is read from the digital display on the Model 1010.

f. The oscilloscope screen may be calibrated in terms of absolute power by depressing the DBM push button. The horizontal center line represents 0 dBm and the display sensitivity is a function of the vertical sensitivity of the oscilloscope. A vertical sensitivity setting of 1V/division would result in a display sensitivity of 10 dB/division. The digital display reading is not useful when sweeping rapidly in this mode.

3.6.3 RATIOING. Two Model 1010 units may be used to ratio two signals in the log mode in either swept or single frequency operation. Test connections for ratioing the signals are shown in Figure 3-1. The Model 1010 has been designed so that no sensitivity adjustments are required when two instruments are used to make ratio measurements. The ratioed signal may be measured in the DB or DB-NULL modes by depressing the appropriate button of the Model 1010 (Unit A Figure 3-1). The second Model 1010 (Unit B Figure 3-1) is operated in the DB or DBM mode.



CONNECTIONS FOR RATIOING TWO SIGNALS

FIGURE 3-1

SECTION 4

PERFORMANCE CHECKS

4.1 EQUIPMENT REQUIRED.

The following equipment is needed to check the performance of the Model 1010:

a. A ratio transformer with at least 0.01% resolution at 1 kHz.

b. A precision thermal converter with at least 0.03% calibration accuracy and approximately 5 mV output for 1 volt rms input.

c. An oscillator covering the frequency band from 10 Hz to 5 MHz with at least 2 volt rms output and a 70 dB attenuator. The entire oscillator to have 0.1% flatness or adjustment capability and the attenuator to be at least 1% accurate.

d. A differential or digital voltmeter with 0.01% resolution and capable of measuring 300 microvolts with 3% accuracy.

e. A precision power supply capable of supplying ± 0 to 6 V into 4000 Ω with 100 μ V resolution.

4.2 INITIAL TURN-ON.

a. Connect the line cord. Be sure that it is properly grounded.

b. Set the rear panel DISPLAY TRIGGER switch to INT.

c. Turn the POWER switch to ON. The digital display should light immediately.

d. After a fifteen minute warmup, depress the 10 MV button and check that the digital display indicates 0.00 MV with the input shorted. If it does not, set the digital display to read 0.00 MV using the ZERO adjustment.

4.3 INPUT ACCURACY CHECK.

Apply 1 V rms from the oscillator at a frequency of 1 kHz to the INPUT connector. Measure the input voltage as precisely as possible using the thermal converter. Depress the 100 Hz MINIMUM FREQUENCY button. Select full scale sensitivities as indicated in Table 4-1 by depressing the appropriate button and determine that the digital display reading falls in the range indicated.

TABLE 4-1

INPUT ACCURACY TEST PARAMETERS

Full Scale Sensitivity Setting	Digital Display Reading
1 V	1.000 ± 6 mV
10 V	1.00 ± 20 mV

4.4 LINEARITY CHECK.

Connect the ratio transformer between the voltage source and the INPUT connector. The thermal converter must remain connected to the voltage source and its output voltage must be monitored to assure that the ratio transformer does not disturb the voltage setting. With 1 V applied to the INPUT jack of the Model 1010, depress the DB button, move the OFFSET selector lever to REF and adjust the digital display to indicate 00.0 DB by means of the OFFSET knob. Table 4-2 indicates the digital display readings to be expected, both in linear and in dB, for various input ratios.

TABLE 4-2

LINEARITY TEST PARAMETERS

Ratio	Full Scale Sensitivity	Digital Display: Linear Reading	Digital Display: DB Reading Ref. 0 - 1V
1.000	1 V	1.000V ± 6mV	00.0dB
0.100	100 mV	100.0mV ± 0.6mV	-20.0dB ± 0.2dB
0.010	10 mV	10.00mV ± 0.09mV	-40.0dB ± 0.2dB
0.001	10 mV	1.00 mV ± 0.05mV	-60.0dB ± 0.7dB

4.5 DBM CHECK.

Using the setup as in Section 4.4, set the ratio to 1.000 and depress the DBM button. With the DBM 1 MW REF switch in the 600 Ω position the digital display should indicate 00.0 DBM ± 0.4 dB.

Set the ratio to .2236 and move the DBM 1 MW REF switch to the 50 Ω position. The digital display should indicate 00.0 DBM ± 0.4 dB.

4.6 DB-EXPAND CHECK.

With the setup as in Section 4.4, set the ratio to be 1.000, depress the DB button and check to see if the digital display indicates 00.0 DB. If not, adjust it to indicate 00.0 DB with the OFFSET control.

Depress the DB-EXP button and move the OFFSET selector lever to the EXP position. Adjust the digital display to indicate 0.00 DB. Table 4-3 indicates the digital display readings to be expected for various input ratios.

TABLE 4-3

DB-EXPAND TEST PARAMETERS

Ratio	Digital Display Reading
.794	2.00 dB ± .1 dB
.631	4.00 dB ± .1 dB
.501	6.00 dB ± .1 dB

4.7 OUTPUT VOLTAGE CHECK.

With the setup as in Section 4.4, set the ratio to be 1.000, depress the DB button and measure the voltage at the OUTPUT jack. Record that reading. Set the ratio to be 0.100. The voltage at the OUTPUT jack should be 2.000 V ± 15 mV more negative than the previous reading.

4.8 FREQUENCY RESPONSE CHECK.

With the setup as in Section 4.2, depress the 1 V button. Table 4-4 indicates the digital display reading to be expected for various input frequencies.

TABLE 4-4

FREQUENCY RESPONSE TEST PARAMETERS

Input Frequency	Digital Display Reading
1 kHz	1.000 V ± 6 mV
10 kHz	1.000 V ± 6 mV
100 kHz	1.000 V ± 6 mV
1 MHz	1.000 V ± 11 mV
5 MHz	1.000 V ± 31 mV

SECTION 5

APPLICATION INFORMATION

5.1 GENERAL.

The Pacific Measurements Model 1010 provides a direct digital readout of ac signals over a wide frequency and amplitude range either linearly or in dB. This unique instrument makes many types of measurements previously difficult or impossible.

5.2 USE OF DIGITAL DISPLAY.

The digital display provides sufficient resolution and accuracy to make full use of the capabilities of the wide range linear detector. The digital display is highly valued in production applications where it may be read quickly by inexperienced personnel. The digital display provides a computer coded output which permits direct on-line computer processing of the data as it is acquired. The wide dynamic range and high frequency capability of the Model 1010 provides measurement capability up to 5 MHz and down to 300 microV for ac signals.

In addition, the unique capability of the Model 1010 to provide a direct digital dB display makes the instrument invaluable for many applications where the convenience of the digital display has been unavailable. Insertion loss, gain, flatness of response, and attenuation are all quantities more conveniently expressed in dB than in linear values. In this mode of operation, the resolution of the display is constant over the entire dynamic range of operation. The BCD output can directly feed a printer or computer to record the signal level in dB.

5.3 USE WITH AN OSCILLOSCOPE OR RECORDER.

The output of the Model 1010 is provided to drive an oscilloscope or X-Y recorder. The output coefficient is 10 dB/V, which is a high enough level to allow a display sensitivity of 1 dB per division on almost any oscilloscope or recorder. The fast response and wide dynamic range of amplitude and frequency make the Model 1010 useful in a variety of applications. Some typical ones follow:

a. Swept Frequency Testing of Filters through the Video Frequency Band.

b. Measurement of the Response of I.F. Amplifiers.

c. Shock and Vibration Testing of Mechanical Systems.

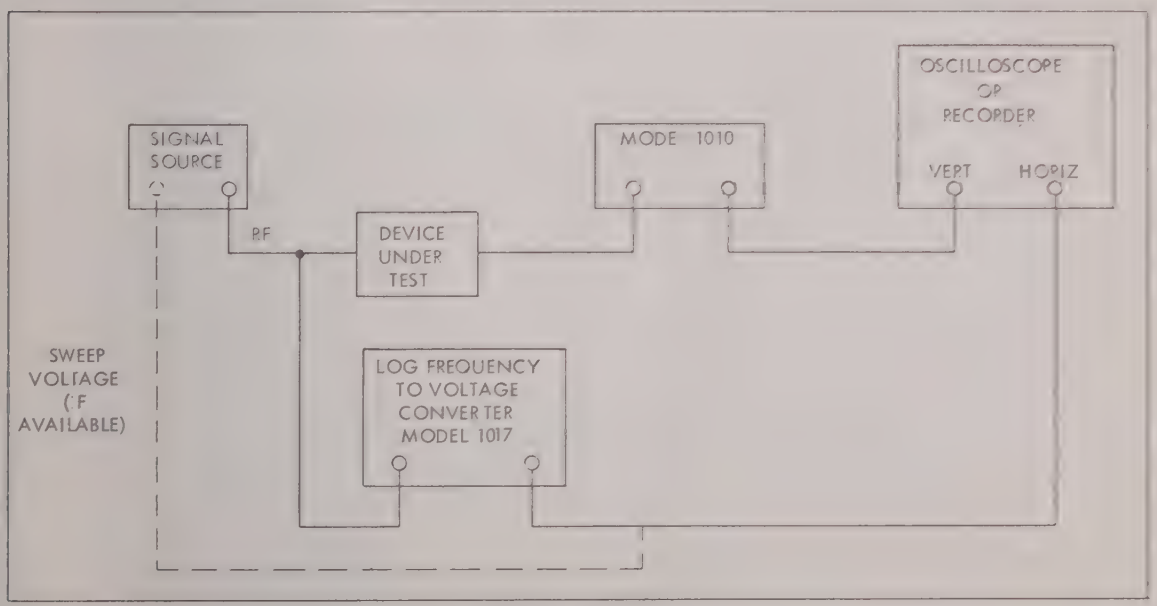
d. Audio Sound Level Measurements across a Wide Band of Frequencies.

e. Response Testing of Audio and Video Frequency Amplifiers. Figure 5-1 shows a typical setup.

f. Loop gain measurements in feedback amplifiers are simplified because the loop gain is plotted directly in dB and phase information can quickly be inferred from such plots.

g. Frequency response of I.F. Amplifiers whose center frequency is much above the 5 MHz limit of the Model 1010 but whose bandwidth is less than 10 MHz, may be measured by mixing a test signal from the filter or I.F. Amplifier with a fixed signal tuned to the center frequency of the amplifier or filter, the output of the mixer may then be applied to the Model 1010 and measured. The only precaution is to be sure that the mixer is operated in its linear detecting range.

h. Signals in High Impedance Circuits. The input capacity of the Model 1010, in addition to the capacity of the shielded cable generally necessary to hook up to a circuit under test, may be excessive if the circuit has a very high impedance. In order to minimize the effect of loading, the Model 1010 has been made to have an input impedance similar to that found on most oscilloscopes. Thus, accessory probes of the



SWEPT FREQUENCY RESPONSE TESTING

FIGURE 5-1

type supplied by oscilloscope manufacturers may be connected to the input of the Model 1010. These probes typically divide by 10 (though larger division ratios are also manufactured) and provide input capacitance at the probe tip of the order of 10 pF. This level of loading is normally tolerable and even with a division ratio of 10 at the input, the Model 1010 will still respond accurately to signals as low as 3 millivolts rms.

5.4 GROUNDING.

The INPUT GROUNDING switch allows the internal circuits and the INPUT connector shell to be isolated from (EXT position) or connected to (INT position) the chassis ground. A three wire power cord connects the instrument chassis to the ground pin of a standard power receptacle.

In some cases the power cord ground provides an unwanted signal return path to the signal source. This will often be the case when testing a device which has a large signal loss, such as a filter in the stop-band, or an attenuator. The difficulty will be reduced if the cables used in the test setup are made as short as possible. In addition the ground loop may be broken if only one of the instruments in the measurement setup is grounded. The INPUT GROUNDING switch may be set to EXT to isolate the Model 1010 from the power line ground. If this is done there should be another path to the power line ground in the measurement connections to insure operator safety and avoid unwanted power line pickup.

It should be noted that no direct connection between the measurement ground and the ground connection of an oscilloscope monitoring the output of the Model 1010 is required. The normal power cord ground is ordinarily satisfactory to provide the oscilloscope ground. Eliminating a direct connection isolates signal currents from the oscilloscope ground. The relatively large output signal available from Model 1010 (10 dB/V) causes the small potentials between the oscilloscope and the Model 1010 measurement circuitry to be insignificant by comparison. The OUTPUT connector shell is connected to the instrument chassis. As a result of this arrangement it is required that the measurement setup be grounded somewhere to the power line ground when operating the instrument with the INPUT GROUNDING switch in the EXT position.

SECTION 6

CIRCUIT DESCRIPTION

6.1 GENERAL.

For purposes of description the Model 1010 may be divided into the following sections:

a. Ac to dc converter.

b. Log/lin amplifier.

c. Digital display unit.

6.2 AC TO DC CONVERTER.

A simplified block diagram of the AC-DC Converter is shown in Figure 6-1. The technique of detection used is a familiar one employing a mixer, driven by a large signal source, operating on an input signal to produce an output proportional to the input but at a frequency equal to the difference between the input signal frequency and the drive signal frequency. In this case, the drive signal is also derived from the input signal and is in phase with it, but its amplitude is large and independent of the input signal amplitude. Since its frequency and phase are the same as the input signal, the difference frequency is 0 and the output amplitude is equal to one over π times the peak input signal amplitude.

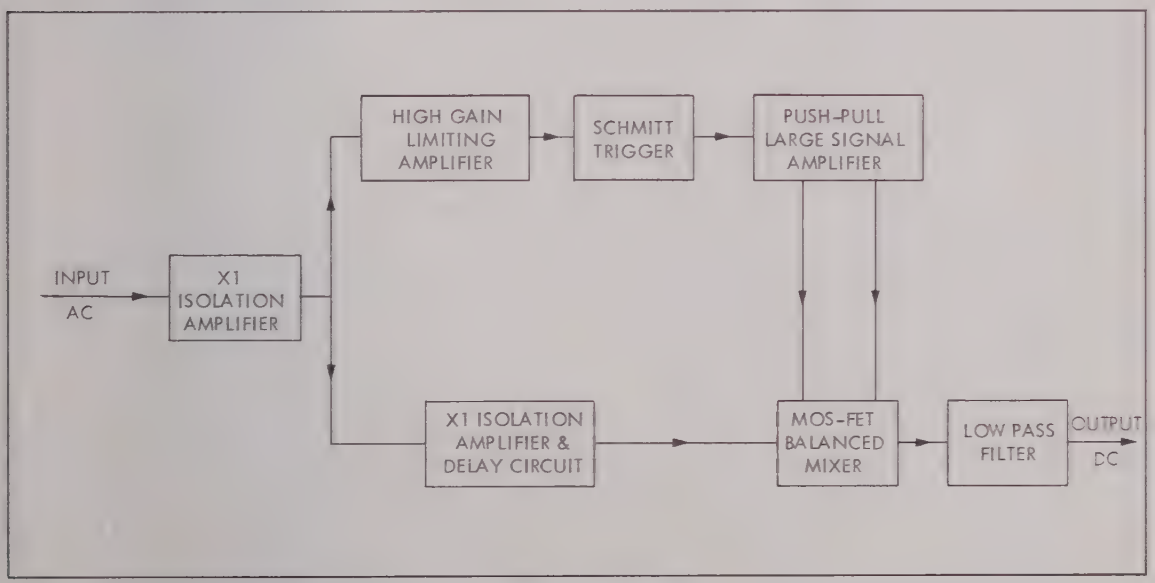
In order to employ a linear mixing detector for a zero difference frequency application, the detector itself must generate no dc voltage. MOS-FET's are used to construct a mixer with exceedingly high balance and, consequently, no dc output in the absence of an input signal. This type of detector provides the very high degree of linearity required by this application. The linearity of the mixing detector is perfect in theory and in practice defies measurement because of the limitations of the best available test equipment.

The following description relates to the block diagram, Figure 6-1. The input signal to the instrument is first supplied to an input attenuator. This permits the instrument to be used with signals larger than the maximum signal for which the detector is still linear, specifically, 2 volt rms. The input attenuator is a constant impedance type so that oscilloscope accessory probes may be used in conjunction with it. A unity gain amplifier isolates the input from the rest of the circuitry. The signal then splits into two paths--one directly to the detector by way of a delay line and the other to a high gain amplifier.

The high gain amplifier is specifically designed to provide carefully controlled clipping characteristics. The amplifier gain is sufficient to cause it to limit on almost all signal levels supplied to the instrument. The limiting action of the amplifier is feedback regulated to cause the output waveform to be symmetrical and closely in phase with the input waveform. The output of this amplifier feeds a Schmitt trigger which generates square waves of exceedingly small rise time. An output amplifier develops the necessary differential (push-pull) signal required by the mixer (demodulator). This signal is applied to the gates of the FET's.

In order to compensate for the small, but discrete, delay introduced in the high gain amplifier, a Chebychev filter is connected between the output of the input amplifier and the mixer input. The delay introduced by this filter is approximately 30 ns. A very low driving impedance is required by the mixer at its small signal input. Accordingly, a grounded collector amplifier is connected between the filter and the input to the mixer.

The mixer consists of a pair of MOS type field effect transistors connected in a series-shunt configuration. The detected signal then feeds an output filter which removes the input frequency component but preserves the dc. This filter may be selected to provide fast response when it is only required to reject relatively high frequencies, and a somewhat slower response when forced to reject lower frequencies.



AC-DC CONVERTER
SIMPLIFIED BLOCK DIAGRAM

FIGURE 6-1

6.3 LOG/LIN AMPLIFIER.

The heart of the Logarithmic Converter is a highly stable operational amplifier with an exponential element in its feedback loop. The operational amplifier has very good phase stability and is chopper stabilized to reduce input drift to a very low level. The exponential element used is a silicon transistor. It is a property of the silicon transistor that if it is operated with zero volts between collector and base, that the collector current is given by the following equation:

$$I_c = I_s \exp \frac{q V_{eb}}{kT} - I_s \qquad (6\text{-}1)$$

Where V_{eb} is more than about .1 volt, the equation reduces to:

$$I_c = I_s \exp \frac{q V_{eb}}{kT} \text{ for } V_{eb} > .1V \qquad (6\text{-}2)$$

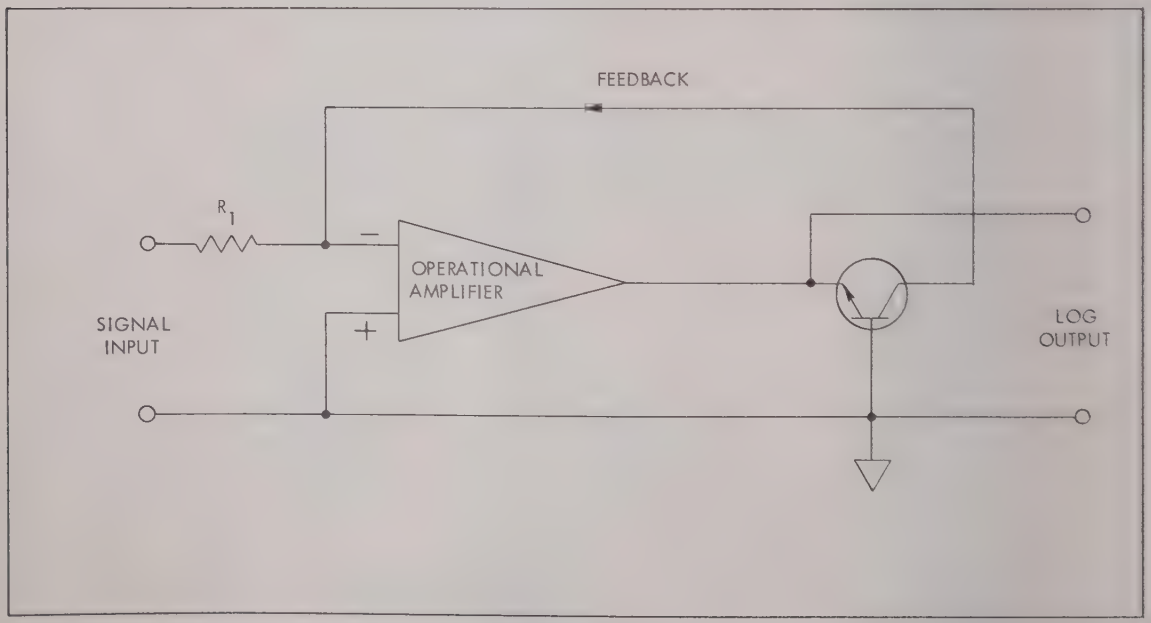
These equations are quite well known, of course, but the significant point is that they hold over a range of some six to ten decades provided the collector to base voltage is maintained very close to zero. If the collector to base voltage is quite large, parasitic sources of the collector current will make the equations inaccurate. In the Model 1010, the collector of the logging transistor is connected directly into the input of the operational amplifier and its emitter is connected to the output of the logging amplifier. Since the amplifier has very high gain, the collector voltage is held very close to zero. The amplifier is designed with very low input leakage currents so that the collector current of the logging transistor is equal and opposite to the input current supplied through the input summing resistor R1 (shown in Figure 6-2) and the output voltage can be written as:

$$E_o = V_{eb} \frac{kT}{q} \ln \frac{E_{in}}{R_1 I_s} \qquad (6\text{-}3)$$

It can be seen from Equation (6-3) that the output voltage is a function not only of the input voltage but also the quantities I_s and the temperature T. Since I_s is in itself dependent upon temperature, the temperature variation of the output voltage is a fairly complicated function. In order to make the output voltage independent of temperature, the logging transistor is placed in a precisely controlled proportional oven. The oven temperature is maintained very close to 51°C. At this temperature the output voltage of the transistor will change 64 millivolts for a decade change of input voltage.

The input operational amplifier is stabilized by means of a chopper amplifier. The ac voltage at the summing junction of the operational amplifier is fed to a FET modulator where it is converted to approximately 600 Hz. The ac signal is amplified by an ac coupled amplifier and demodulated by a transistor switch. The resulting dc voltage at the demodulator output will be an amplified, and drift free, replica of the voltage at the summing junction. This voltage is fed into the operational amplifier as a correction signal, cancelling any drift voltages appearing at the input of the operational amplifier.

The oven temperature is automatically controlled by a feedback regulator. The sensing element for the feedback regulator is a thermistor. Voltage changes in the thermistor are amplified and cause current changes in a transistor mounted in the oven. A constant voltage is supplied to the transistor in the oven and the power it dissipates is proportional to the current through it. Thus, the transistor provides gain for the amplifying circuit and heat to operate the oven. A current



LOGGING CIRCUIT

FIGURE 6-2

limiting resistor, R_2, keeps the current from rising to an excessive value during turn-on from a cold start. See Figure 6-3.

Since 64 millivolts per decade change is not a convenient number and also since it represents only 3.2 millivolts per decibel which is too small to be handled conveniently, an amplifier is applied across the terminals of the logging transistor to increase this to 100 mV/dB.

6.4 DIGITAL DISPLAY.

6.4.1 GENERAL DESCRIPTION. The Pacific Measurements Digital Display is used to convert the analog signals developed by the instrument into digital form for direct readout using gas filled display tubes. In addition, it generates Binary Coded Decimal (BCD) signals which can be used with data acquisition systems.

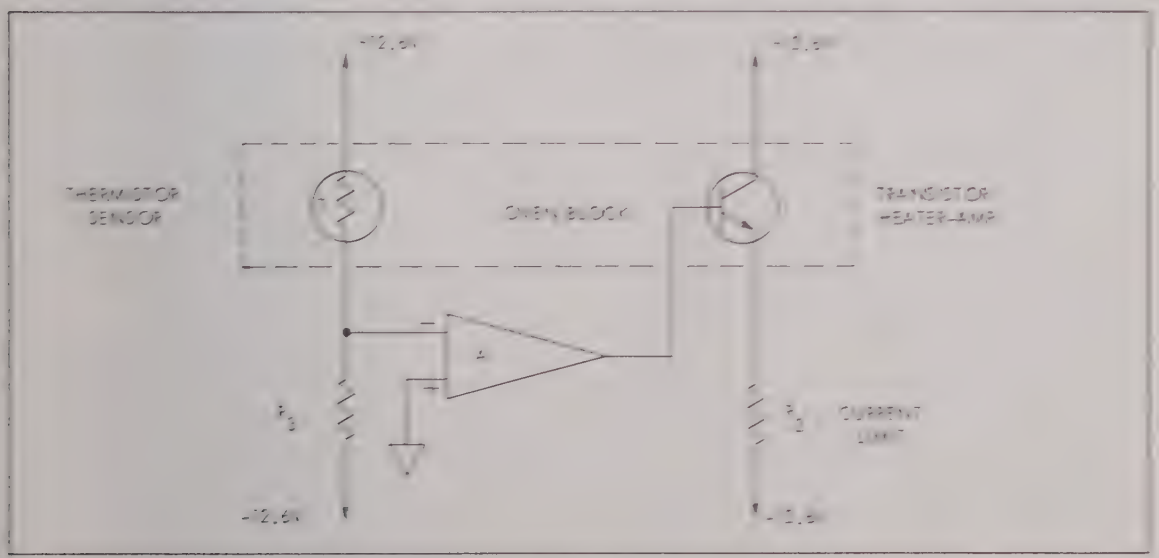
In order to provide high speed, excellent long term stability and to make use of readily available, off-the-shelf integrated circuits, the digital display uses a successive approximation process in order to generate a display. The logic functions of the instrument are performed by integrated circuits. The actual process of approximation is done by transistor switches controlling high stability, precision resistors. Specialized integrated circuits are used to drive the display tube numerical indicators.

For descriptive purposes, the digital display unit can be broken down into four elements. The first, and fundamental, element is the reference supply which forms the standard for comparison against which all input voltages are measured. The second is the approximation circuit which generates the current to balance the current developed by the input voltage applied across the input resistor. The third is the comparator which generates the control signals to be applied to the approximation circuit. The fourth part of the system can be described broadly as the logic circuitry which provides the control information to permit the approximation process to proceed in an orderly, sequential fashion. In principle, the process of successive approximation is merely an automatic way of doing what an operator of a differential voltmeter does by hand. The user of a differential voltmeter measures an input voltage by obtaining an approximate null; setting the most significant digit on the instrument first and then progressively refining the approximation by setting successively less significant digits, until all available digits have been set.

In the Pacific Measurements Digital Display, the process of approximation is carried out in a BCD sequence, that is, all the numbers from zero through nine are derived by adding the Binary numbers 0 1 2 4 8 to form each decade. In order to form three decades, twelve non-zero numbers are required. Since the Pacific Measurements Digital Display also has the capability of displaying the overrange 1, an additional number is required for a total of 13. The approximation circuit consists of 13 solid state switches connected to 13 precision resistors. If a switch is actuated, it will connect one end of the resistor to a precise reference voltage. The opposite end of each resistor is tied to a common point together with a precision resistor leading to an input voltage. In addition, a high gain, integrated circuit differential amplifier monitors this point to serve as a null detector, or comparator.

The approximation process is performed under control of the logic circuit, so that the resistor corresponding to the most significant Binary digit is selected first, then the next significant digit and so on until the least significant digit has been determined. By proceeding in this fashion, advantage may be taken of the fact that each binary digit which is not in excess of the input is required in the answer. Thus, the logic circuits first connect a given resistor to the reference supply, the comparator determines whether the current through the resistor is greater or less than that required to produce a null. If it is greater, the logic disconnects the resistor; if it is less, the resistor remains connected. At the end of the approximation process, resistors are connected between the null point and the reference supply to correspond to BCD numbers equal to the input voltage. The control voltages applied to the switches are also the BCD output, and they are decoded into decimal form to drive the display tubes.

Since the approximation process operates in one direction only, the instrument will accept signals of only one polarity at its input. In order to permit measurements of signals of both polarities and to isolate the rest of the instrument from noise generated in the digitizing process, an "absolute value circuit" is included in the system. If a negative input is



OVEN CONTROLLER

FIGURE 6-3

applied to the instrument, the input resistor is connected through a non-inverting amplifier to the voltage to be measured. If a positive voltage is applied to the input, the input resistor is connected through the inverting amplifier to the input voltage. A pair of diodes connected back to back operate to select the appropriate signal path. Thus, the input resistor will always be driven negative, independent of the polarity of the signal applied. In addition, a voltage is generated to light either the plus or the minus indicator in accordance with the input signal polarity.

6.4.2 REFERENCE SUPPLY. Refer to the circuit diagram 10843, sheet 1, in Section 8. The reference supply is a high gain dc amplifier. The input stage of the amplifier is a temperature stable silicon dual NPN transistor. On the input side of the amplifier is the voltage reference consisting of the temperature stable Zener diode (CR8) and a resistive divider network. R82 through R84 are resistors which may be selectively shorted out in order to center the potentiometer (R87) to obtain precisely 4 V at the input of the amplifier. This permits the potentiometer to have small range so that the reference may be set to within 1 mV. The output voltage of the power supply is fed for comparison against the reference. A condenser, C8, stabilizes the power supply and provides a low impedance at high frequencies. In order to insure long term stability, the Zener diode is aged for several days prior to installation. If a replacement Zener is installed, the output voltage of the power supply should be checked and reset, if necessary, after a few days of operation as there is appreciable voltage change across a Zener diode during its first few hours of operation after which further voltage changes are slight and occur at a very slow rate.

6.4.3 APPROXIMATION CIRCUIT. The approximation circuit consists of silicon PNP transistors operated as switches and driven from the logic circuitry. In order to minimize the voltage drop across the transistors when they are conducting, transistors corresponding to the eight most significant Binary digits are connected so that the collector serves as the emitter in the ON state. Furthermore, for the four most significant digits, a two stage switch is used with a second transistor supplying most of the current to the summing resistor. The primary switch transistor will then have little current flowing through it, thus a very small voltage drop will develop across its parasitic resistances. Each transistor switch is driven from an NPN transistor referenced to ground whose base is supplied with a signal from the logic circuitry. Resistors of very high precision are used in the most significant digits. Digits of less significance make use of resistors of somewhat less precise value.

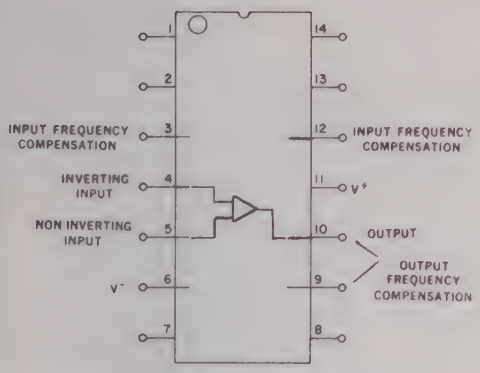
6.4.4 COMPARATOR. A high gain, integrated circuit differential amplifier monitors the summing junction of the approximation circuit. The amplifier is connected so that it inverts the input signal. Since the input to the instrument must always be negative and the feedback signal from the approximation signal is positive, the comparator will have a negative output voltage if the current supplied by the approximation circuit is larger than the input current, and a positive output voltage if the current supplied by the approximation circuit is less than the input current.

6.4.5 LOGIC. By far the most complex portion of the logic circuitry is concerned with the commutation process. In order for the process of successive approximation to proceed in an orderly fashion, it is necessary for the logic circuits to generate control signals which successively connect to the reference voltage resistors corresponding to the most significant digit down through the least significant. Actually, this process must be repeated twice for each resistor. That is, each resistor must be connected to the reference voltage and a short time later disconnected if it is not required in the approximation. Each solid state switch is connected to the output of a JK flip-flop. The flip-flop performs two functions. First, it transfers information placed at its input to its output during, but only during, a negative transition of the clock fed to its timing input. Second, it will store information until new data is fed to it and it receives an additional clock pulse. This permits all of the set and clear inputs to the JK flip-flops in the storage section to be connected in parallel. Thus, a command to close the solid state switch may be fed to all flip-flops but only one receiving a clock pulse will respond to it. Likewise, a command to disconnect may also be fed to all of the flip-flops without affecting any but the desired one. Thus, much of the circuitry is concerned with generating pairs of pulses which occur at progressively later times during the measurement cycle.

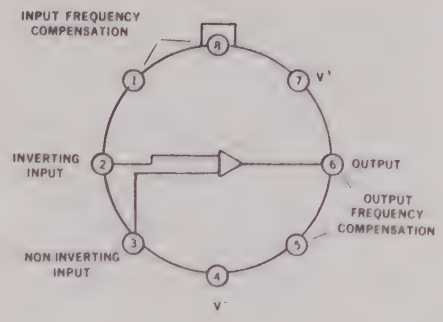
A multivibrator serves as a clock operating at approximately 75 kHz. The output of the clock is fed into a succession of five flip-flops which divide by 32; at the end of the 32nd pulse the last flip-flop overspills, triggering a sixth flip-flop which terminates the process. A succession of AND gates and inverters are connected to the complementary outputs of the four flip-flops following the first one to provide 13 separate successive outputs, each with just one pulse occurring during the process. These are combined with the clock pulses to produce 13 separate signals each consisting of a pair of clock pulses occurring at progressively later times during the measurement cycle. These clock pulses are fed to JK flip-flops controlling the solid state switches in the approximation circuit.

During the negative transition of the first clock pulse of each pair, a signal is applied to the input of all JK flip-flops in the storage section of the unit such as to produce a switch closure. However, only one of the flip-flops is receiving a clock pulse at that time and, consequently, only one switch closes. During the second clock pulse a signal derived from the comparator is applied to the input of all JK flip-flops which causes the resistor to be disconnected during the next clock pulse if the output of the comparator is negative. If the output of the comparator is positive, this signal does not appear and the resistor remains connected. This process starts with the resistor corresponding to the overrange "1" digit and ends with the resistor corresponding to 1 in the last column. The instrument then remains dormant until a new measurement command arrives. The measurement command is a pulse applied to the preset terminals of all flip-flops which resets them to their zero state, permitting the count-down process to begin again. A one-shot multivibrator generates this pulse. A Schmitt trigger drives the one-shot multivibrator. In order to permit the system to free run, the output of the Schmitt trigger also is fed to a capacitor and from the capacitor back to the input of the Schmitt. The capacitor alternately charges and discharges between hysteresis limits of the Schmitt permitting continuous free running operation. Alternatively, the Schmitt may be triggered from an external signal source at frequencies up to 1 kHz.

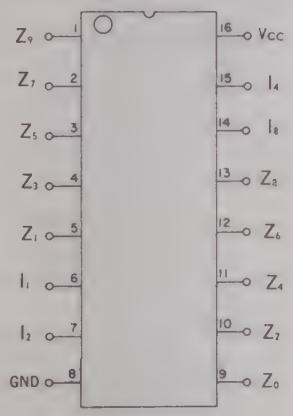
6.4.6 INTEGRATED CIRCUITS. A variety of integrated circuits are used in this instrument. They are standard RTL circuits. Circuit diagrams are shown in Figure 6-4 and Figure 6-5 for your reference. Additional information regarding them is available from the manufacturer. The type numbers shown are manufacturers numbers. Individual instruments may have devices of other manufacturers installed and the type numbers may not agree with those shown.



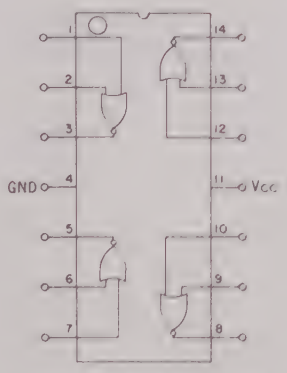
MC1709C Operational Amplifier



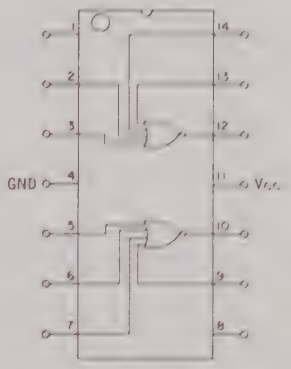
MC1709C Operational Amplifier



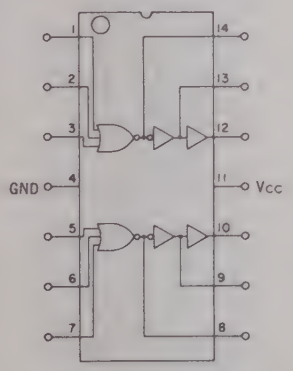
CμL 9960 Decoder/Driver



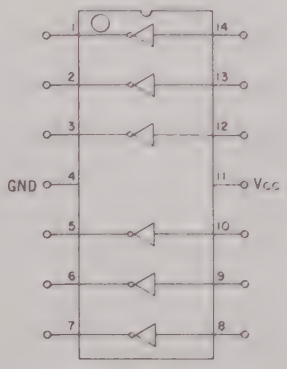
MC724P — Quad 2-Input Gate



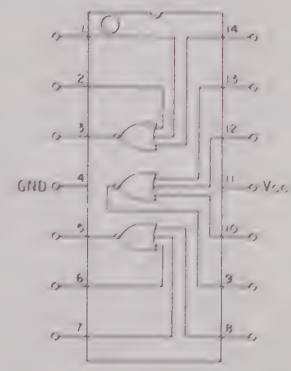
MC725P — Dual 4-Input Gate



MC788P — Dual Buffer



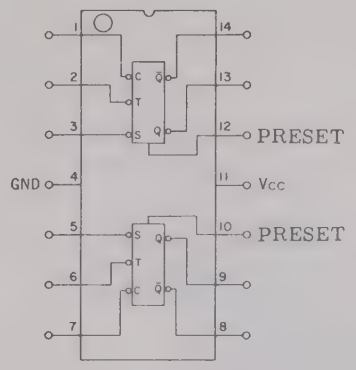
MC789P — Hex Inverter



MC792P — Triple 3-Input Gate

INTEGRATED CIRCUITS

FIGURE 6-4



MC790P — Dual J- K Flip-Flop

Truth Table

Clock T	Set S	Clear C	T=n+1 Q
0	Lo	Lo	$\overline{Q^n}$
0	Lo	Hi	Lo
0	Hi	Lo	Hi
0	Hi	Hi	Q^n

INTEGRATED CIRCUIT

FIGURE 6-5

SECTION 7

MAINTENANCE

7.1 PERIODIC MAINTENANCE.

The following maintenance should be performed once a year unless the instrument is operated in an extremely dusty or chemically contaminated environment or is subjected to severe abuse. In such cases, more frequent maintenance is indicated.

a. Blow out all accumulated dust with forced air under moderate pressure. Be particularly careful to clean the area in the vicinity of the approximation resistors of the digital display. Any scum or grime in this region may have to be removed with a suitable solvent specified for this purpose.

b. Inspect the instrument for loose wires and damaged components. Check to see that all plug-in PC boards are properly seated in their connectors.

c. Make a performance check in accordance with the procedure of Section 4, "Performance Checks."

7.2 INTERNAL ADJUSTMENTS AND TEST POINTS.

Under normal conditions none of the internal adjustments should need adjusting except after a repair of a failure.

CAUTION

Do not attempt to make any adjustments on this instrument until you have read the following section completely. Some adjustments interact and must be made in the proper sequence or the instrument will not perform properly. Many of the voltages to be measured are not with respect to ground; therefore, a voltmeter with a floating input must be used.

7.2.1 DESCRIPTION OF ADJUSTMENTS. The function of each adjustment is described below. Refer to Figure 7-1 for the location of each adjustment.

a. A1R9, +12.6 V POWER SUPPLY CALIBRATION ADJUSTMENT. Used to set this positive power supply to +12.6 V ± 10 mV.

b. A1R18, -12.6 V POWER SUPPLY CALIBRATION ADJUSTMENT. Used to set this negative power supply to -12.6 V ± 10 mV.

NOTE: The -12.6 V power supply must be set before the +12.6 V power supply calibration adjustment is adjusted.

c. A2R3, ZERO SET. Used to set the display to zero for zero input voltage.

d. A2R87, +4.000 V ADJUSTMENT. Used to set the reference supply to +4.000 V ± 1 mV.

e. A3R4, NEGATIVE INPUT AMPLIFIER BALANCE ADJUSTMENT. Used to adjust the negative input amplifier to have zero output from zero input.

f. A3R20, POSITIVE AMPLIFIER BALANCE ADJUSTMENT. Used to adjust the positive amplifier for zero output with zero volts input.

g. A4R18, INPUT ZERO ADJUSTMENT. Used to set the summing junction of the input amplifier to zero volts.

h. A4R63, INPUT CURRENT BALANCE ADJUSTMENT. Used to compensate for leakage current in the input amplifier input transistor.

i. A4R67, LINEAR CALIBRATE ADJUSTMENT. Used to calibrate the linear ranges.

j. A4R83, 10 MV/DB ADJUSTMENT. Used to calibrate the log modes.

k. A4R91, X10 BALANCE ADJUSTMENT. Used to balance the expansion amplifier.

l. A4R101, RATIO CALIBRATE ADJUSTMENT. Used to set the sensitivity of the RATIO INPUT to 100 mV/dB.

m. A4R104, 20 DB OFFSET CALIBRATE ADJUSTMENT. Used to set exactly 20 dB of offset when the input attenuator is in the 10 volt position.

n. A4R111, NULL CALIBRATE ADJUSTMENT. Used to set the output for exactly 1.0 Volts/10 dB change in null offset.

o. A4R114, 0 DBM CALIBRATE FINE ADJUSTMENT. Used to set the output to zero volts with 0.775 volts input.

p. A4R116, 0 DBM CALIBRATE COARSE ADJUSTMENT. Used to set the output to zero volts with 0.775 volts input.

q. A4R124, OUTPUT BALANCE ADJUSTMENT. Used to adjust the output amplifier for zero volts output with zero volts input.

r. A4R132, OVERRANGE CALIBRATE ADJUSTMENT. Used to set the point at which the overrange circuit changes to 10 volt scale.

s. A4R156, 0 DBM CALIBRATE 50 Ω ADJUSTMENT. Used to set the output to zero volts with 0.224 volts input.

t. A6R16, SQUARE WAVE SYMMETRY ADJUSTMENT. Used to set the symmetry of the square wave at TP61 (A6J1) with 100 mV input.

u. A6R45, SCHMITT SYMMETRY ADJUSTMENT. Used to set the Schmitt bias for symmetrical output with 300 μV input.

v. A6R65, 10 VOLT CALIBRATE ADJUSTMENT. Used to set the input attenuator to exactly 20 dB.

7.2.2 TEST POINTS. Refer to Figure 7-1 for location of the test points.

a. TP1(A1J1), +12.6V. Measure between +TP1 and floating ground, -TP2. +12.6 V ± 10 mV, ripple less than 0.5 mV peak to peak at 115 V ac line.

b. TP2(A1J2), FLOATING GROUND.

c. TP3(A1J3), -12.6 V. Measure between -TP3 and floating ground, +TP2. -12.6 V ± 10 mV, ripple less than 0.5 mV peak to peak at 115 ac line.

d. TP4(A1), AUXILIARY POWER SUPPLY. Measure between +TP4 and +12.6 V, -TP1. ~~2.5~~ ± ~~5.0~~ 3.00 V, ripple less than ~~50~~ mV peak to peak at 115 V ac line.

e. TP5(A1), PRIMARY REFERENCE VOLTAGE. Measure between TP5 and floating ground, TP2, 5.9 V to 6.5 V.

f. TP11(A4J1), CHOPPER DEMODULATOR OUTPUT. Measure between TP11 and ground, TP16. When the demodulator switch is closed, the waveform should be a clean 0 V. When the demodulator is open, approximately .05 V peak to peak noise should be present.

g. TP12(A4J2), INPUT AMPLIFIER SUMMING JUNCTION. Measure between TP12 and signal ground, TP16. Set to 0 V with the input zero adjustment, A4R18.

h. TP13(A4J3), LOG TRANSISTOR OUTPUT. Measure between TP13 and signal ground, TP16.

i. TP14(A4J4), OVEN HEATER CURRENT. Measure between TP14 and -12.6 V, TP3. Voltage should be approximately 1.5 V immediately after turn on and settle to less than 0.4 volts within 5 minutes.

j. TP15(A4J5), LOG POST AMPLIFIER OUTPUT. Measure between TP15 and signal ground, TP16. Set A4R83 for 10 mV/dB.

k. TP16(A4J6), SIGNAL GROUND.

l. TP17(A4J7), 20 DB OFFSET SWITCH. Connect TP17 to signal ground, TP16 to check 20 dB offset operation.

m. TP18(A4J8), EXPAND AMPLIFIER OUTPUT. Measure between TP18 and signal ground, TP16. Set to 0 V with A4R91 when TP15 is at 0 V.

n. TP21(A2J1) DIGITAL DISPLAY INPUT.

o. TP22(A2J2) DIGITAL DISPLAY GROUND.

p. TP23(A2J3), +3.6 V. Measure between TP23 and TP22 +3.6 V ± 200 mV.

q. TP24(A2J4), +4.000 V. Measure between TP24 and TP22. +4.000 ± 1 mV. Ripple less than 0.5 mV peak to peak at 115 V ac line.

r. TP25(A2J5) CLEAR LINE. Used to provide the trigger source for an oscilloscope when checking logic circuitry. Also indicates the proper operation of the frequency divider.

s. TP26(A2J6), PRESET LINE. Used to check for proper operation of the preset one-shot multivibrator.

t. TP27(A2J7), SET LINE. Used to check for proper operation of the comparator.

u. TP31(A3J1), DIGITAL DISPLAY PREAMP OUTPUT. Measure between TP31 and TP22(A2J2).

v. TP61(A6J1), CLIPPER AMPLIFIER OUTPUT. Measure the waveform between TP61 and signal ground TP16.

w. TP62(A6J2), DEMODULATOR OUTPUT. Measure the waveform between TP62 and signal ground, TP16.

7.3 CALIBRATION.

7.3.1 EQUIPMENT REQUIRED. To calibrate the Model 1010, the following equipment is required.

a. A differential or digital voltmeter with 10 µV resolution and 0.01% accuracy.

b. An oscilloscope with at least 1 mV/cm sensitivity and at least 500 kHz response.

c. A ratio transformer with at least .01% resolution at 1 kHz.

d. A precision thermal converter with at least .03% calibration accuracy at 1 V rms input.

e. An oscillator covering 10 Hz to 5 MHz with at least 2 V rms output into 50 Ω and at least 0.1% adjustment capability.

f. A precision attenuator adjustable up to 70 dB, which is flat within ±0.1% to 5 MHz.

g. A precision power supply capable of supplying ±0 to 6 V into 4000 Ω with 100 µV resolution.

7.3.2 CALIBRATION PROCEDURE. The following steps must be performed in the order indicated.

a. Adjust the -12.6 V power supply. Adjust the voltage between +TP2 (A1J2) and -TP3 (A1J3) with A1R18 to be -12.6 V ± 10 mV.

b. Adjust the +12.6 V power supply. Adjust the voltage between +TP1 (A1J1) and -TP2 (A1J2) with A1R9 to be +12.6 V ± 10 mV.

c. Check +3.6 V supply. Measure between +TP23 (A2J3) and -TP22 (A2J2), +3.6 V ± 200 mV.

d. Adjust the +4.000 V supply. Adjust the voltage between +TP24 (A2J4) and -TP22 (A2J2) with A2R87 to be +4.000 V ± 1 mV.

e. Adjust the digital display to zero. Place the DISPLAY TRIGGER switch in the INT position. Disconnect the output of the input amplifier board by removing the lead from Terminal 15 (A2).

CAUTION

Be very careful to grasp the metal portion of the jack with a pair of pliers. Do not pull on the wire.

Connect the positive side of the precision power supply to TP22 (A2J2) and the negative side to Terminal 15 (A2). Adjust A2R3 until transition from zero to 1 occurs between 1.5 and 2.5 mV. Disconnect the precision supply and reconnect the output of the input amplifier to Terminal 15 (A2).

f. Disconnect the lead to the digital display preamplifier at terminal 22 (A4). Connect the output of the precision supply between this lead (-) and signal ground, TP16 (A4J6) (+). Connect the precision voltmeter to TP31 (A3J1) and signal ground, TP16 (A4J6). Set the power supply to 2.00 mV and adjust A3R4 for a reading of -8.00 mV ± 0.5 mV on the voltmeter.

g. Reverse the polarity of the power supply and adjust A3R20 for a reading of -8.00 mV at TP 31.

h. Increase the output of the power supply to 1.000 V. The digital display should read 1.000. A slight readjustment of A2R87 may be required to produce this

reading. Disconnect the power supply and voltmeter and replace the lead on terminal 22 (A4).

i. Place the front panel zero adjustment in the center of its range. Depress the 100 Hz MINIMUM FREQUENCY button and the 1 V button. Apply 100 mV at approximately 1 kHz to the INPUT jack. Connect a voltmeter between TP12 (A4J2) and signal ground TP16 (A4J6). Adjust A4R18 for zero volts ± 10 µV. Disconnect the voltmeter.

j. Connect the oscilloscope between TP61 (A4J1) and signal ground, TP16 (A4J6). Adjust A6R16 for perfect symmetry of the square wave. Disconnect the oscilloscope.

k. Connect the output of the oscillator to the thermal converter and the input of the ratio transformer. Set the oscillator for exactly 1.000 V as measured with the thermal converter. Set the ratio transformer for 0.1000. Depress the 100 mV button. Adjust A4R67 for a reading of 100.0 mV on the digital display.

NOTE: When using the ratio transformer, a low pass filter with a cutoff at approximately 50 kHz must be inserted at the Model 1010 INPUT jack since high frequency, low level interference will influence the reading.

l. Depress the 10 mV button. Connect a voltmeter to the OUTPUT jack of the Model 1010. Set the ratio transformer to 0.0003 (300 µV) and adjust A6R45 for a maximum reading on the voltmeter. Then adjust A4R63 for a reading of 0.30 mV on the digital display.

m. Depress the 1 V button and set the ratio transformer to 0.1000 (100 mV). Note the reading of the voltmeter connected to the OUTPUT jack. Depress the 10 V button and set the ratio transformer to 1.000 (1 V). Adjust A6R65 so that the voltmeter reads the same as before.

n. Set the ratio transformer to 0.100 (100 mV). Depress the 100 mV button. Increase the frequency of the applied signal to 10 kHz. Set the oscillator output for a reading of 100.0 mV on the digital display. Disconnect the input cable and insert a 40 pF capacitor in series with the input. Set the ratio transformer to 0.200 (200 mV) and adjust A6C22 for a reading of 100.0 mV on the digital display. Remove the 40 pF capacitor.

o. Disconnect the ratio transformer and 50 kHz filter and apply 100 mV at 1 MHz to the INPUT jack of the Model 1010. Note the reading of the digital display. Increase the frequency to 5 MHz, maintaining 100 mV and adjust A6C33 so that the digital display reads the same as before. Due to a slight effect at 1 MHz it is desirable to repeat this procedure.

p. Apply 10 mV at 1 MHz. Depress the 10 mV button. Adjust A6C40 for the best frequency response between 1 MHz and 5 MHz.

q. Depress the 10 V button and apply 1 V at 10 kHz. Connect a voltmeter to the OUTPUT jack. Adjust A6C23 for best frequency response from 10 kHz to 100 kHz.

r. Set the oscillator at 1 V at 10 kHz. Note the reading of the voltmeter connected to the OUTPUT jack of the Model 1010. Disconnect the input cable and insert a 40 pF capacitor in series with the input. Adjust A6C27 for a reading on the voltmeter of exactly half the preceding reading.

s. Depress the DB button and place the DBM 1 MW REF switch in the 600 Ω position. Connect the oscillator through the ratio transformer and low pass filter to the INPUT jack of the Model 1010. Set the oscillator to 1 kHz at 1.0 V and the ratio transformer to 1.000. Move the OFFSET selector to the REF position and adjust the OFFSET control for a reading of 00.0 dB on the digital display. Set the ratio transformer to 0.010 and adjust A4R83 for a reading of -40.0 dB on the digital display.

t. Set the ratio transformer to 1.000. Depress the DB-EXP button. Connect the voltmeter to TP15 (A4J5) and adjust the OFFSET control for zero volts. Connect the voltmeter to TP18 (A4J8) and adjust A4R91 for zero volts. Connect the voltmeter to the OUTPUT jack and adjust A4R124 for zero volts.

u. Depress the DB-NULL button, move the OFFSET selector to NULL and adjust the OFFSET control for a reading of 00.0 dB. Move the OFFSET selector to REF and adjust the OFFSET control for a reading of zero volts on the meter connected to the OUTPUT jack. Move the OFFSET selector to NULL and set the OFFSET control for a reading of 60.0 dB on the digital display. Adjust A4R111 for a reading of 6.00 volts on the voltmeter. Return the offset to 00.0 dB.

v. Depress the DB push button. Connect the precision supply to the RATIO INPUT connector J8 on the rear of the unit. Set the supply for 0.00 volts. Move the OFFSET selector to REF and adjust the OFFSET control for a reading of 00.0 dB on the digital display. Set the precision supply for 6.00 volts and adjust A4R101 for a reading of 60.0 dB. Disconnect the precision supply.

w. Adjust the OFFSET control for a reading of zero volts ±1 mV on the voltmeter connected to the OUTPUT jack. Connect TP17 (A4J7) to signal ground, TP16 (A4J6). Adjust A4R104 for a reading of 2.000 V ± 1 mV on the voltmeter. Disconnect the wire from TP17.

x. Depress the DBM button and apply exactly 0.775 volts at 1 kHz. Adjust A4R116 (coarse) and A4R114 (fine) for a reading of 00.0 DBM on the digital display.

y. Move the DBM 1 MW REF switch to the 50 Ω position. Change the ratio transformer setting to apply exactly 0.224 V. Adjust A4R156 for a reading of 00.0 DBM on the digital display.

z. Depress the DBM button. Set the oscillator for 0.5 V at 1 kHz. Set the ratio transformer for 1.00. Connect the voltmeter from TP17 (A4J7) to -12.6 V at TP3 (A1J3). Slowly increase the output voltage of the oscillator and note the input voltage at which the voltage at TP17 changes from zero to -0.6 V. Adjust A4R132 until this switch occurs at 1.5 volts. It will be necessary to reduce the input to less than 1 V to reset the circuit.

7.4 TROUBLE SHOOTING.

In order to localize the source of trouble in an instrument such as this, it is necessary to have a rather detailed working knowledge of the instrument. You are urged to read carefully

Section 6 on Circuit Description and make use of the circuit diagrams.

CAUTION

Always turn the power off before removing or inserting an individual PC board. Be sure the PC board is inserted in the connector correctly as indicated in Figure 7-1. If the board is inserted backwards or into the wrong connector serious damage may occur. If the board is operated on an extender, be particularly careful to see that the orientation of Figure 7-1 is observed. It is also important to handle printed circuit boards carefully during removal and insertion so as not to disturb the settings of the potentiometers which are on them.

7.4.1 LOCALIZATION OF TROUBLE. Use Trouble Shooting Table 7-1. Also make use of the test point information in Section 7.2.

After the trouble has been found and corrected, the calibration should be checked as outlined in Section 7.3.

7.4.2 LOCALIZATION OF TROUBLE TO INDIVIDUAL COMPONENTS. To determine whether a component is defective, it may be necessary to make active or passive circuit checks as well as waveform measurements. Where allowed by circuit voltages, the performance of a transistor that is forward-biased can usually be determined by shorting the base to the emitter or by opening the base circuit. The transistor will be turned off in either case unless it is shorted. Performance may be determined by monitoring circuit parameters. A transistor can be assumed to be open if it does not conduct when its base-to-emitter voltage exceeds 0.5 V.

When checking the FETs used in the Model 1000, shorting the source to drain will result in a zero reading if the FET is open. Under normal operating conditions, these FETs operate with a negative bias of less than 2 V between the gate and source and a source to drain voltage of at least 5 V unless the unit is shorted. Ohmmeter measurements may be made on the source-gate junction as long as the precautions mentioned below are observed. Back biased, the source-gate junction should be several mΩ ohms.

Open or shorted transistors may also be located through resistance measurements across the elements. Exact values cannot be given due to the differences in transistors; however, the ratio of forward and backward emitter-collector resistance is normally between 10:1 and 100:1. Higher power transistors have the lower ratios. If it is determined that a transistor is defective, look for other defective elements in the circuit that may have resulted from, or caused the transistor failure.

When checking resistors and diodes out of the circuit, one lead must be disconnected to prevent shunt paths and possible damage to diodes and transistors.

CAUTION

1. USE OF OHMMETER. Some ohmmeters may supply sufficient voltage or current to damage transistors. Before using an ohmmeter to check transistors or to make measurements in transistor circuits, be sure to check the voltage and current output of the ohmmeter on the range to be used. The open circuit voltage should not exceed 1.5 V and the short circuit current should not exceed 3 mA or transistors may be damaged.

2. MEASURING TRANSISTOR VOLTAGES. Do not measure the base-to-emitter voltage of a transistor directly because auxiliary currents may damage the transistor. Measure the voltages independently with respect to ground.

7.5 PARTS REPLACEMENT.

7.5.1 REPLACEMENT OF PARTS ON PRINTED CIRCUIT BOARDS. Before removing a component from a PC board, carefully note its orientation. Use a low wattage soldering iron (25 W maximum) and apply heat sparingly to the component lead. Be sure that the soldering iron is grounded to prevent leakage current from damaging other components. The simplest way to remove a component with three or more leads is to cut the leads and then unsolder the remaining leads from the PC board. Clear the solder from the PC board holes with a toothpick or an awl for ease of insertion of the new component. To replace the component, form and cut the leads so that they extend approximately 0.74" through the PC board when the component is in position. Whenever possible hold the component lead with a tool that will act as a heat sink and solder the lead from the opposite side. Avoid overheating and use a good quality rosin core solder. Cut off excess lead length and clean off any excess flux.

A break in the etched copper conductor may be repaired by soldering a piece of copper wire across the break. If the bond between the etched copper conductor and the base material fails, secure the conductor in place with a cement having good electrical insulating properties.

7.5.2 REPLACEMENT OF PARTS ON THE FRONT PANEL. Parts mounted on the front panel are accessible by removing the top and bottom covers of the instrument. However, complete access to the rear of the front panel may be obtained by removing the four screws in the corners of the panel flanges, the screw in the center of the top flange and the two screws that hold the MINIMUM FREQUENCY switch. The panel may now be pulled away from the remainder of the unit.

7.5.3 REPLACING THE OFFSET POTENTIOMETERS. To replace the OFFSET potentiometers, proceed as follows: Remove the front panel as described in Section 7.5.2. Unsolder the leads from the potentiometer. Remove the OFFSET control knob and the two screws that hold the potentiometer assembly to the panel. Remove the potentiometer assembly from the instrument. Loosen the drive wheel on the potentiometer shaft and the potentiometer retaining nut. The potentiometer may now be removed from the assembly.

7.5.4 REMOVING PLUG-IN PRINTED CIRCUIT BOARDS. The upper portion of the rear panel serves as a hold-down for the two plug-in printed circuit boards. Access to these circuit boards is gained by removing the top cover and the upper portion of the rear panel.

7.5.5 INDICATOR TUBE REPLACEMENT. Access to the indicator tubes is obtained by removing the front panel as described in Section 7.5.2.

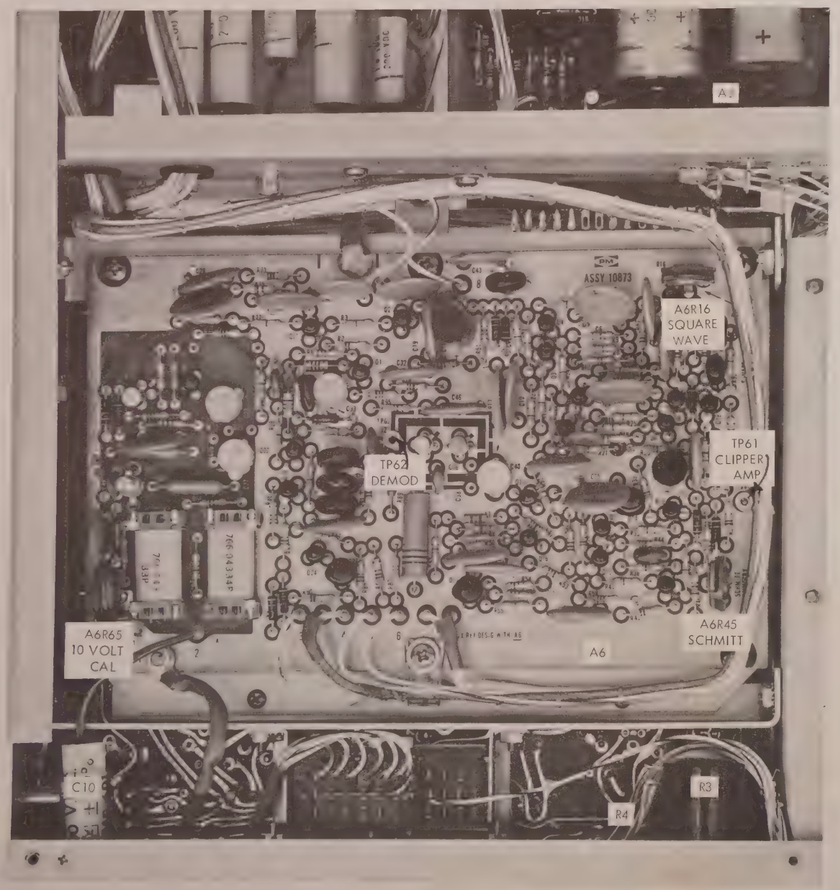
7.5.6 UNIT LAMP REPLACEMENT. To replace the unit lamps, proceed as follows: Remove the front panel as described in Section 7.5.2. Remove the two screws that secure the unit lamp holder to the side bracket. Pry off the white lens of the lampholder with a screwdriver or similar instrument. Note the orientation of the lens so that it may be properly replaced. Remove the defective lamp by gripping it with long nose pliers and pulling it straight out of the lampholder.

7.5.7 ACCESS TO ASSEMBLY A4. Access to the back of Assembly A4 is obtained as follows: Disconnect the four

capacitor lead (C10) from A6 pin 2. Pull on the metal portion of the connector with a pair of pliers. Do not pull on the wire.) Disconnect the ground lead from A6 pin 1 by removing the nut. Remove the two screws that hold the A6 mounting bracket to the switch bracket. The bracket may now be rotated about a pivot for access to the back of A4.

TABLE 7-1 TROUBLE SHOOTING

INDICATION	CHECK
NO DIGITAL DISPLAY	1. Power Cord. 2. Fuse (F1); access to the fuse is through the barrier cover. F1 is 0.5 A 250 V. 3. POWER switch, S1. 4. Transformer, T1. 5. 200 V power supply.
DIGITAL DISPLAY DOES NOT CHANGE	DISPLAY TRIGGER switch (rear panel).
INSTRUMENT PROVIDES MEANINGLESS DISPLAY WITH SEVERAL NUMBERS LIT IN EACH DISPLAY TUBE.	1. Check that the 3.6 V supply is operating TP23 (A2J3). 2. Check the logic circuit. Determine that there are 16 pulses at TP25 (A2J5) each measurement cycle. Look for pairs of pulses at Pins 2 and 6 of A2QA14 thru A2QA19 and at Pin 2 of A2QA20. When checking for logic levels within the instrument, it will be found that they vary considerably from IC to IC. The following levels are limits of operation: 1. A low level input may not exceed 400 mV. 2. A high level signal may not fall below 900 mV. 3. Display Trigger Switch (rear panel)
OUT OF CALIBRATION AT ALL SIGNAL LEVELS.	1. AC to DC converter A6, TP21(A6J1), TP22 A6J2. 2. Power Supplies, A1. 3. Input Amplifier. 4. Post amplifiers, TP13, TP15, TP18. 5. 4,000 V Power Supply Voltage TP24(A2J4). 6. Perform Calibration.
OPERATES CORRECTLY WITH MOST NUMBERS BUT SOME NUMBERS IN ERROR.	Check the components in the approximation circuit corresponding to the numbers in error. Particularly the switching transistor and the summing resistor.
EXCESSIVE LINE FREQUENCY SIGNAL ON OUTPUT.	Grounding of associated test equipment. (Section 5.4)
OUT OF CALIBRATION BELOW 10 mV ONLY.	1. Zero Control. 2. Chopper Amplifier.
OUT OF CALIBRATION IN LOG MODE ONLY.	1. [illegible] Amplifier TP15. 2. Post amplifiers TP13 TP18. 3. Perform Calibration.
INOPERABLE IN LOG MODES ONLY.	Logging Transistor (A4Q10).
WILL NOT RATIO PROPERLY WITH ANOTHER UNIT.	Ratio Input Sensitivity Adjustment (A4R151).
OUT OF CALIBRATION BY 10.8 DB	DBM 1 MW REF switch in wrong position.


A6
ASSY 10873
A6R16
SQUARE
WAVE
TP62
DEMOD
TP61
CLIPPER
AMP
A6R65
10 VOLT
CAL
A6R45
SCHMITT
C10
R4
R3

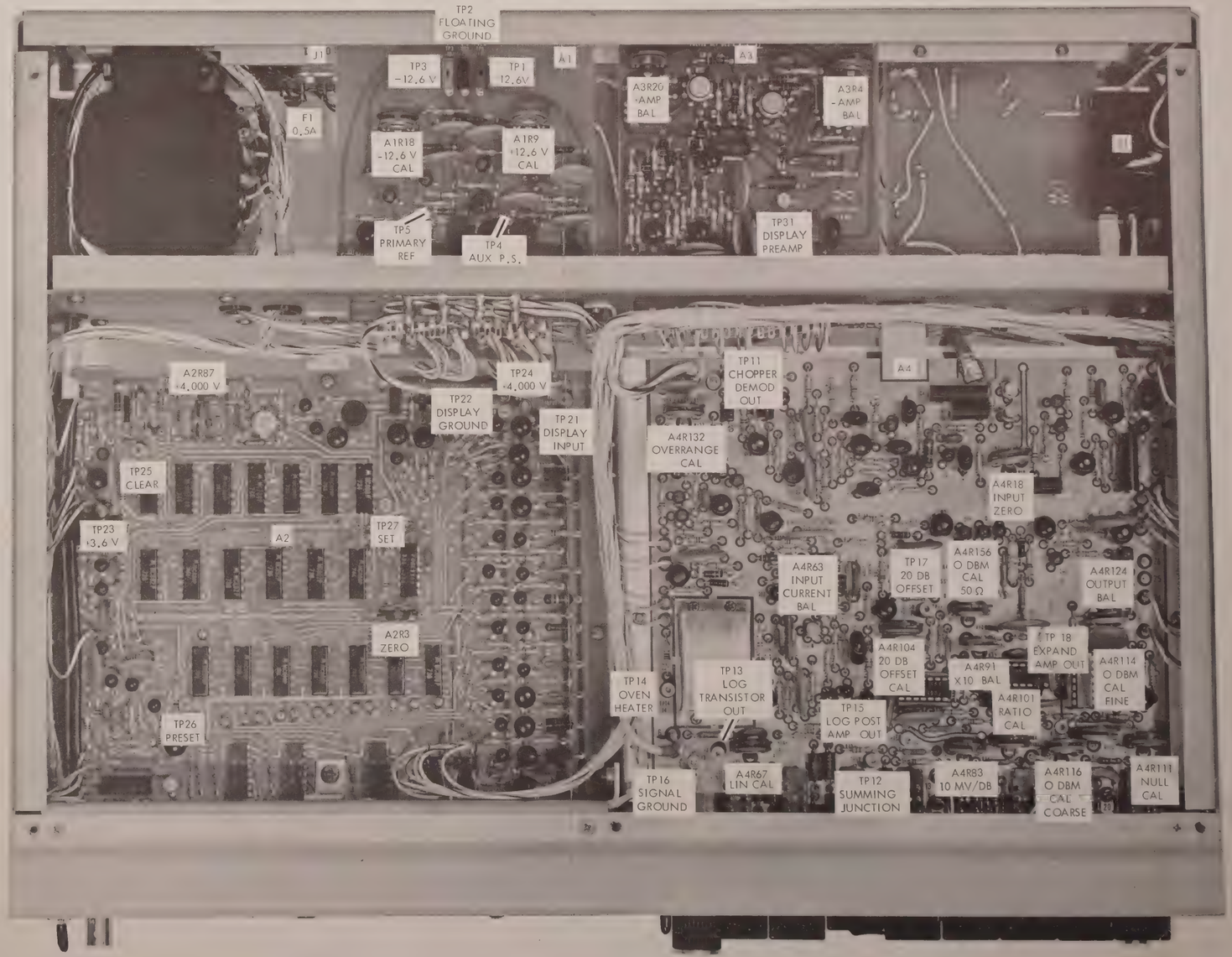
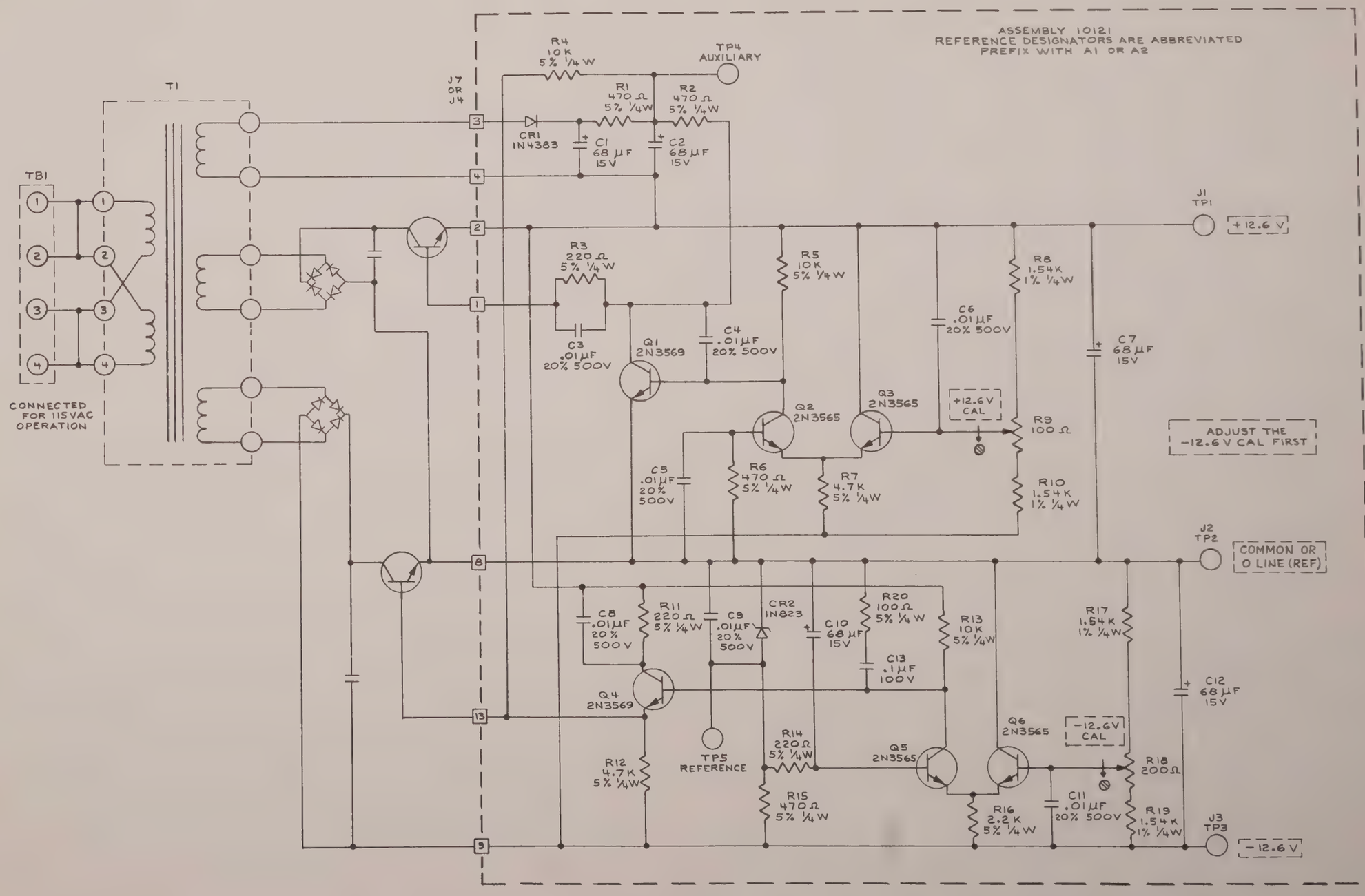

TP2
FLOATING
GROUND
J1
A1
A3
TP3
-12.6 V
TP1
12.6V
F1
0.5A
A1R18
-12.6 V
CAL
A1R9
+12.6 V
CAL
A3R20
-AMP
BAL
A3R4
-AMP
BAL
TP5
PRIMARY
REF
TP4
AUX P.S.
TP31
DISPLAY
PREAMP
A2R87
+4.000 V
TP22
DISPLAY
GROUND
TP24
+4.000 V
TP21
DISPLAY
INPUT
TP11
CHOPPER
DEMOD
OUT
A4
A4R132
OVERRANGE
CAL
TP25
CLEAR
A4R18
INPUT
ZERO
TP23
+3.6 V
A2
TP27
SET
A4R63
INPUT
CURRENT
BAL
TP17
20 DB
OFFSET
A4R156
0 DBM
CAL
50Ω
A4R124
OUTPUT
BAL
A2R3
ZERO
TP 18
EXPAND
AMP OUT
A4R114
0 DBM
CAL
FINE
TP14
OVEN
HEATER
TP13
LOG
TRANSISTOR
OUT
A4R104
20 DB
OFFSET
CAL
A4R91
X10 BAL
A4R101
RATIO
CAL
TP26
PRESET
TP15
LOG POST
AMP OUT
TP16
SIGNAL
GROUND
A4R67
LIN CAL
TP12
SUMMING
JUNCTION
A4R83
10 MV/DB
A4R116
0 DBM
CAL
COARSE
A4R111
NULL
CAL

FIGURE 7-1

SECTION 8

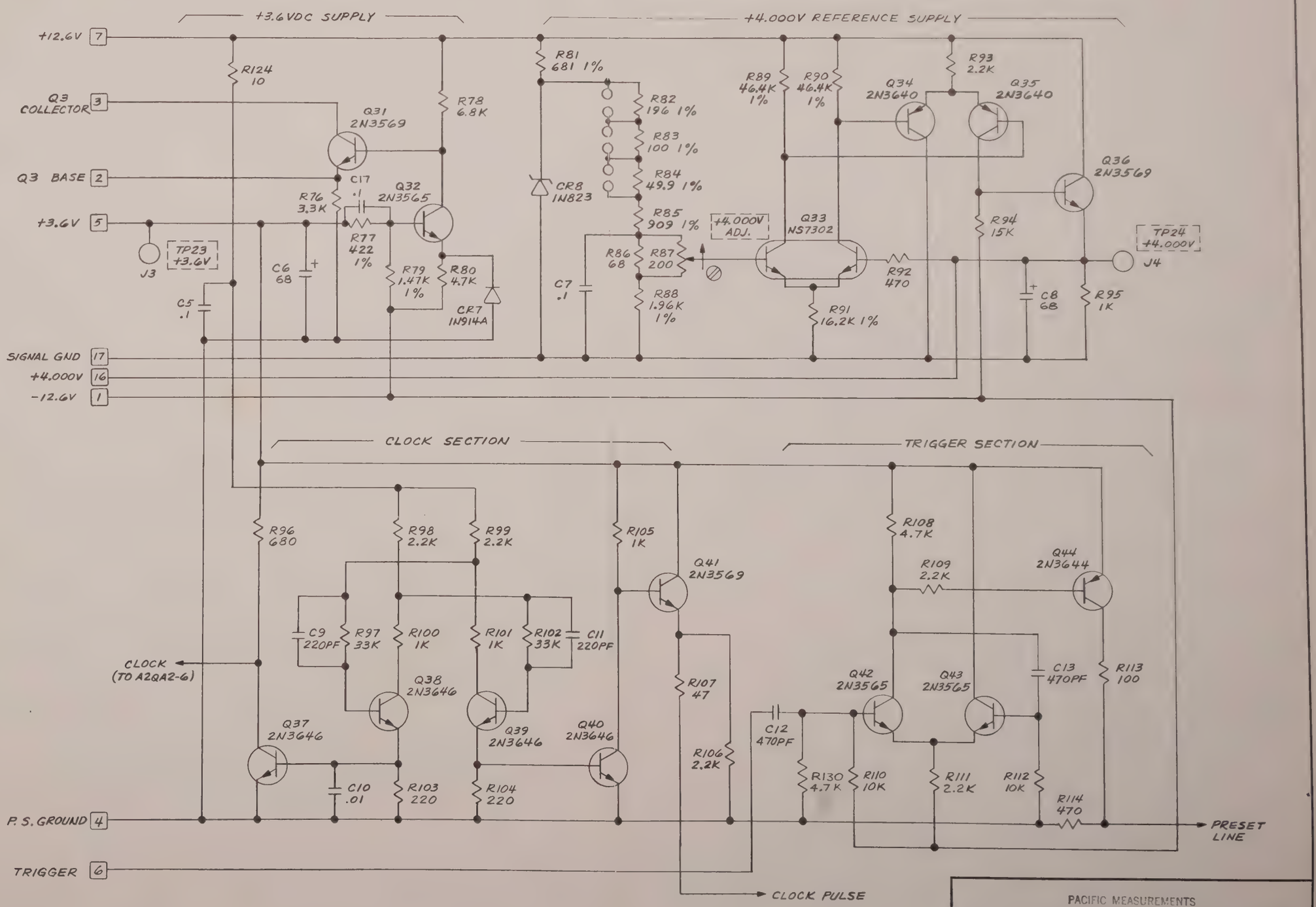
SCHEMATIC DIAGRAMS

± 12.6 V POWER SUPPLY	10420 A1 B2
DIGITAL DISPLAY (3 SHEETS)	10843
PREAMP, POLARITY AND TRIGGER	10847
INPUT CIRCUIT (4 SHEETS)	10868
AMPLIFIER MODULATOR (2 SHEETS)	10883
LOG/LIN AC DIGITAL VOLTMETER	10931



PACIFIC MEASUREMENTS		
SCALE: ——	APPROVED BY: Alan N. Anderson	DRAWN BY AHO
DATE: 1-11-67		REVISED
±12.6 VOLT POWER SUPPLY		DRAWING NUMBER 10420

11X22 PRINTED ON NO. 1000H CLEARPRINT



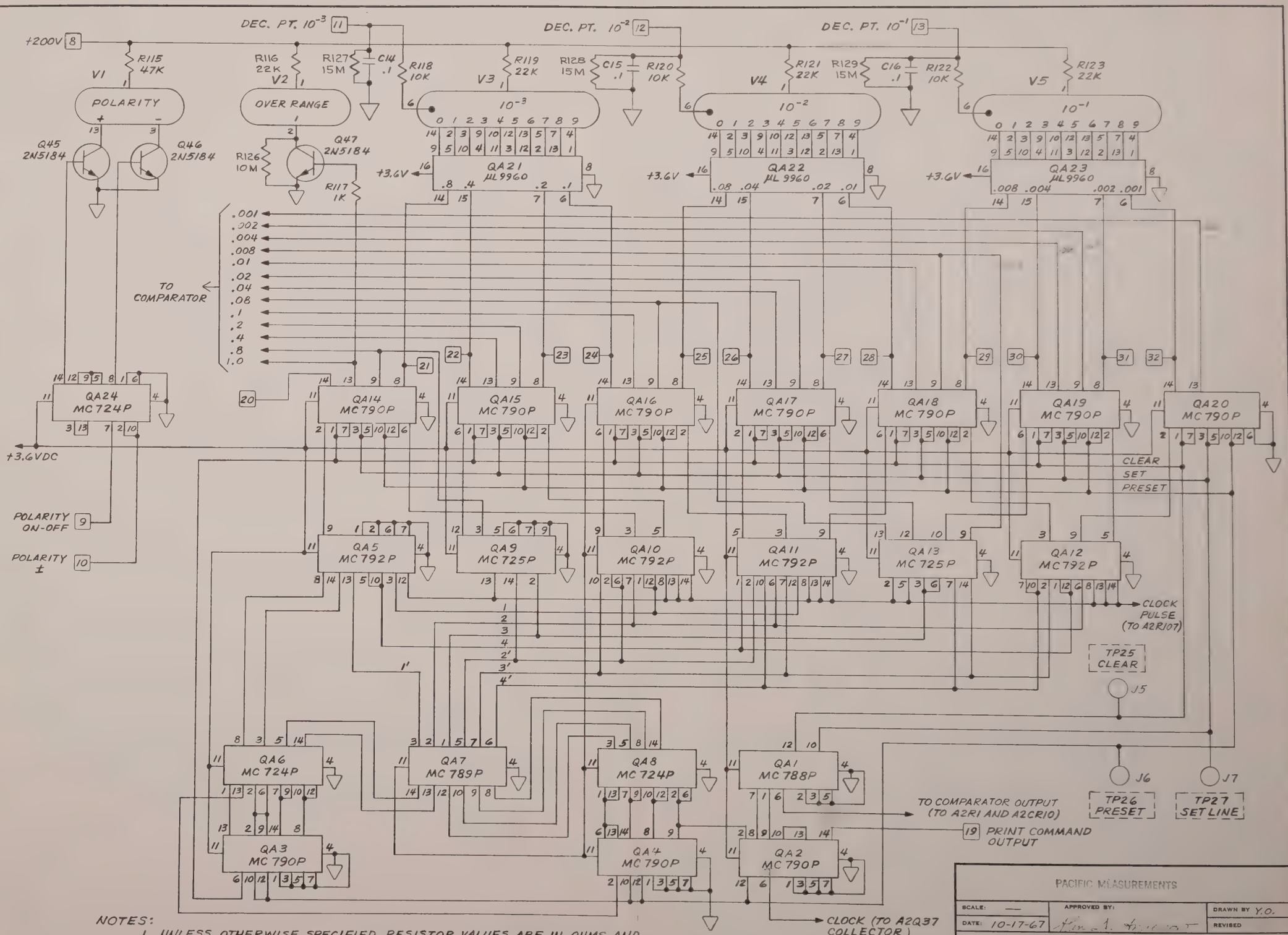
NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE ±5% ¼W. CAPACITOR VALUES ARE IN MICROFARADS.
2. THIS SECTION IS PART OF ASSEMBLY 10776. PREFIX REFERENCE DESIGNATORS WITH A2.

PACIFIC MEASUREMENTS		
SCALE:	APPROVED BY: Alan A. Anderson	DRAWN BY Y.O.
DATE: 11-1-67		REVISED
DIGITAL DISPLAY		
		DRAWING NUMBER 10843

17X88 PRINTED ON NO. 1000H CLEARPRINT

©

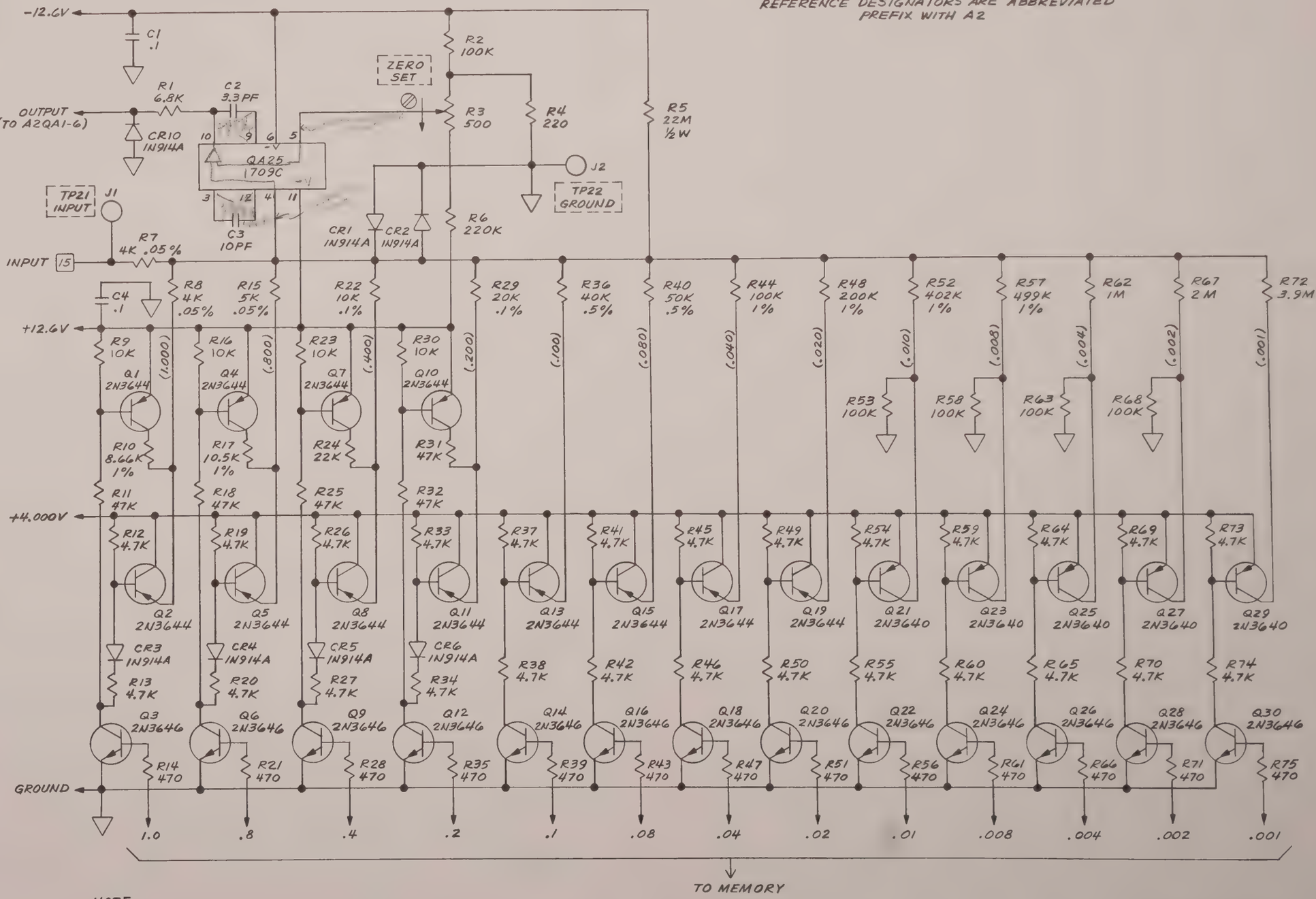


NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.
2. THIS SECTION IS PART OF ASSEMBLY 10776. PREFIX REFERENCE DESIGNATORS WITH A2.

PACIFIC MEASUREMENTS		
SCALE: —	APPROVED BY:	DRAWN BY Y.O.
DATE: 10-17-67	Final Approval	REVISED
DIGITAL DISPLAY - LOGIC SECTION		DRAWING NUMBER 10843

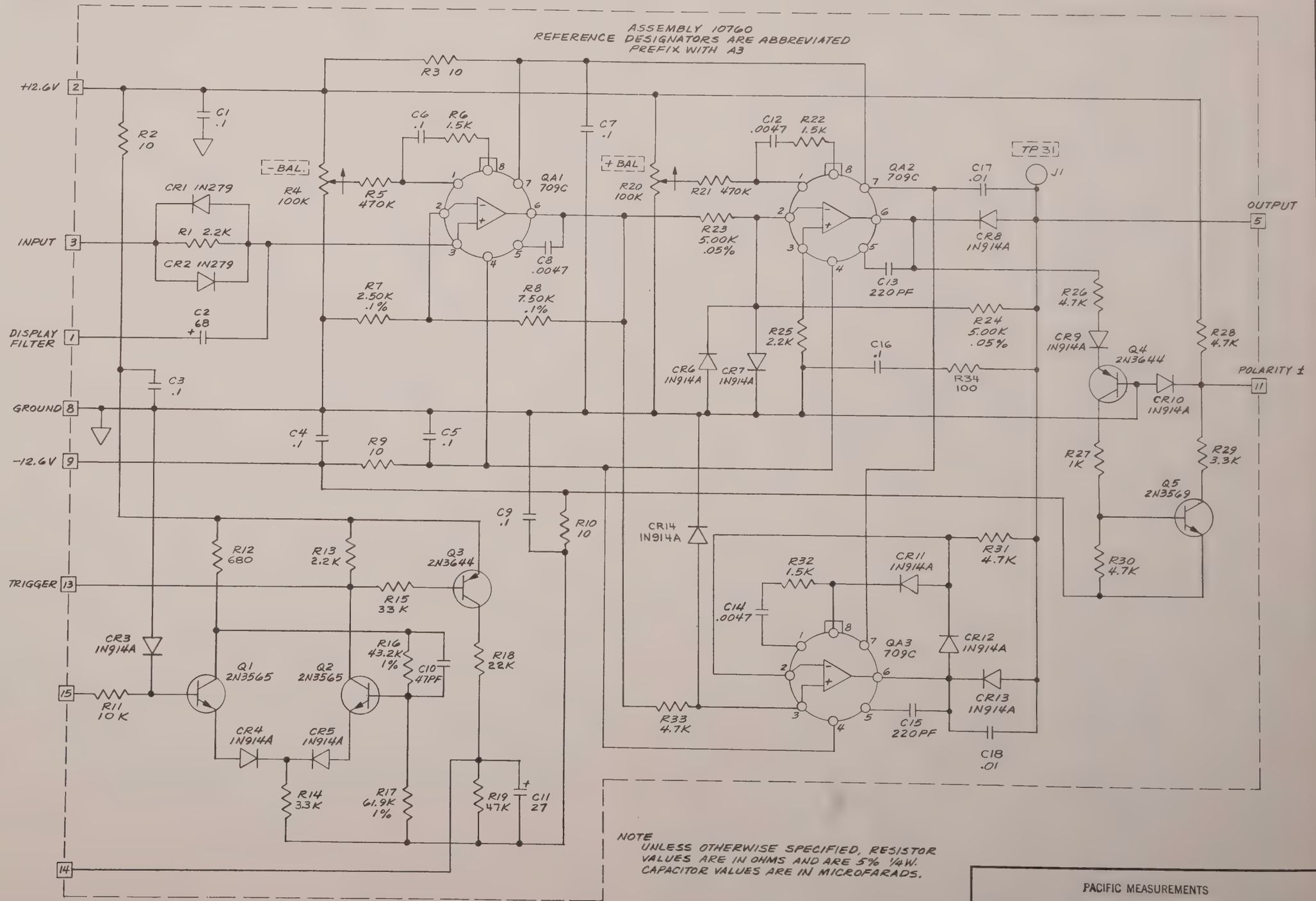
ASSEMBLY A2
REFERENCE DESIGNATORS ARE ABBREVIATED
PREFIX WITH A2



NOTE

UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% ¼W. CAPACITOR VALUES ARE IN MICROFARADS.

PACIFIC MEASUREMENTS		
SCALE:	APPROVED BY: Alan D. Anderson	DRAWN BY Y.O.
DATE: 11-17-67		REVISED
DIGITAL DISPLAY - COMPARATOR		
		DRAWING NUMBER 10843



NOTE
UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.

PACIFIC MEASUREMENTS

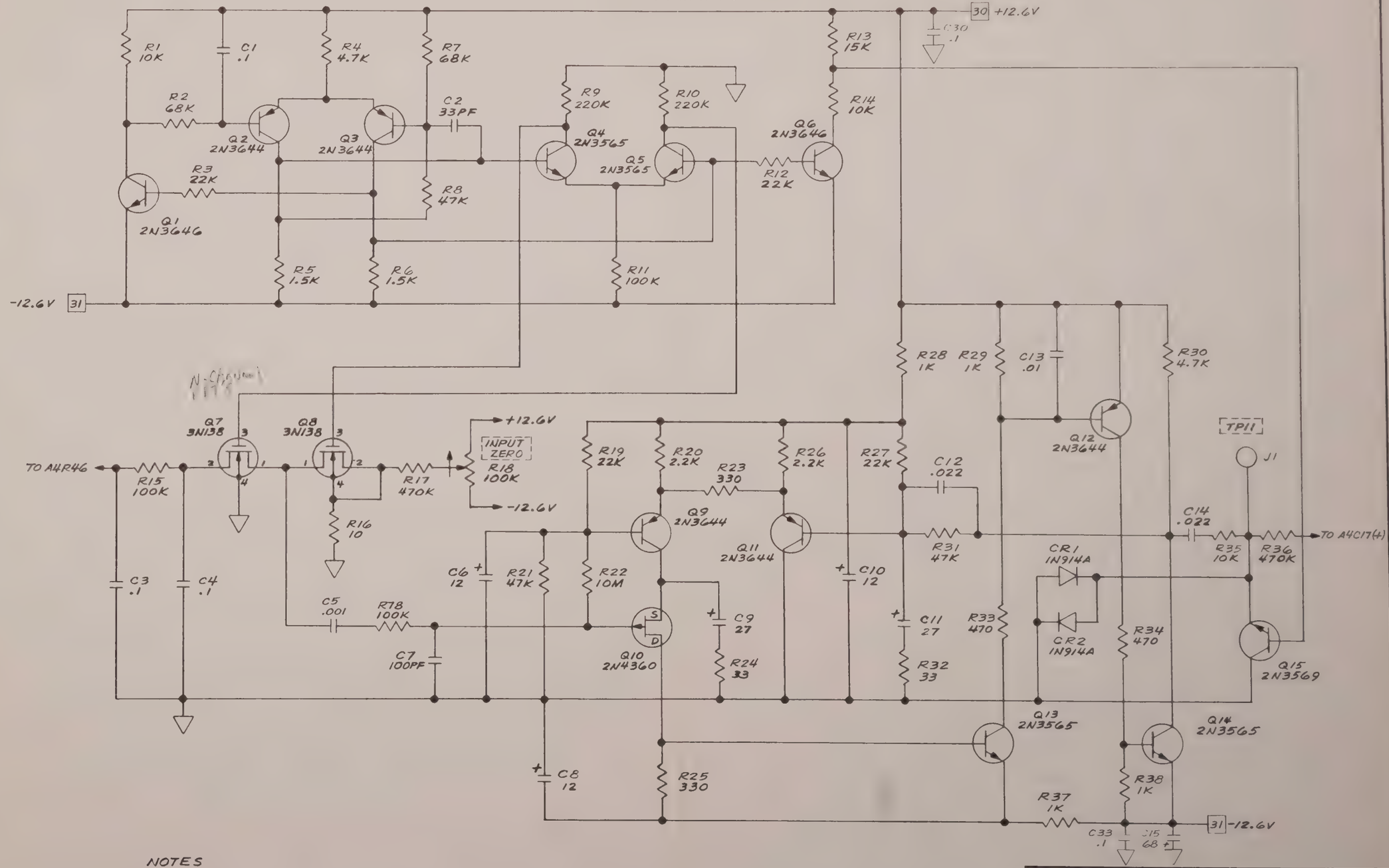
SCALE: —	APPROVED BY: Ralph Britton	DRAWN BY Y.O.
DATE: 4-5-68		REVISED

PREAMP, POLARITY & TRIGGER CIRCUIT

DRAWING NUMBER 10847

17X22 PRINTED ON NO. 1000H CLEARPRINT

ASSEMBLY 10859
REFERENCE DESIGNATORS ARE ABBREVIATED
PREFIX WITH A4

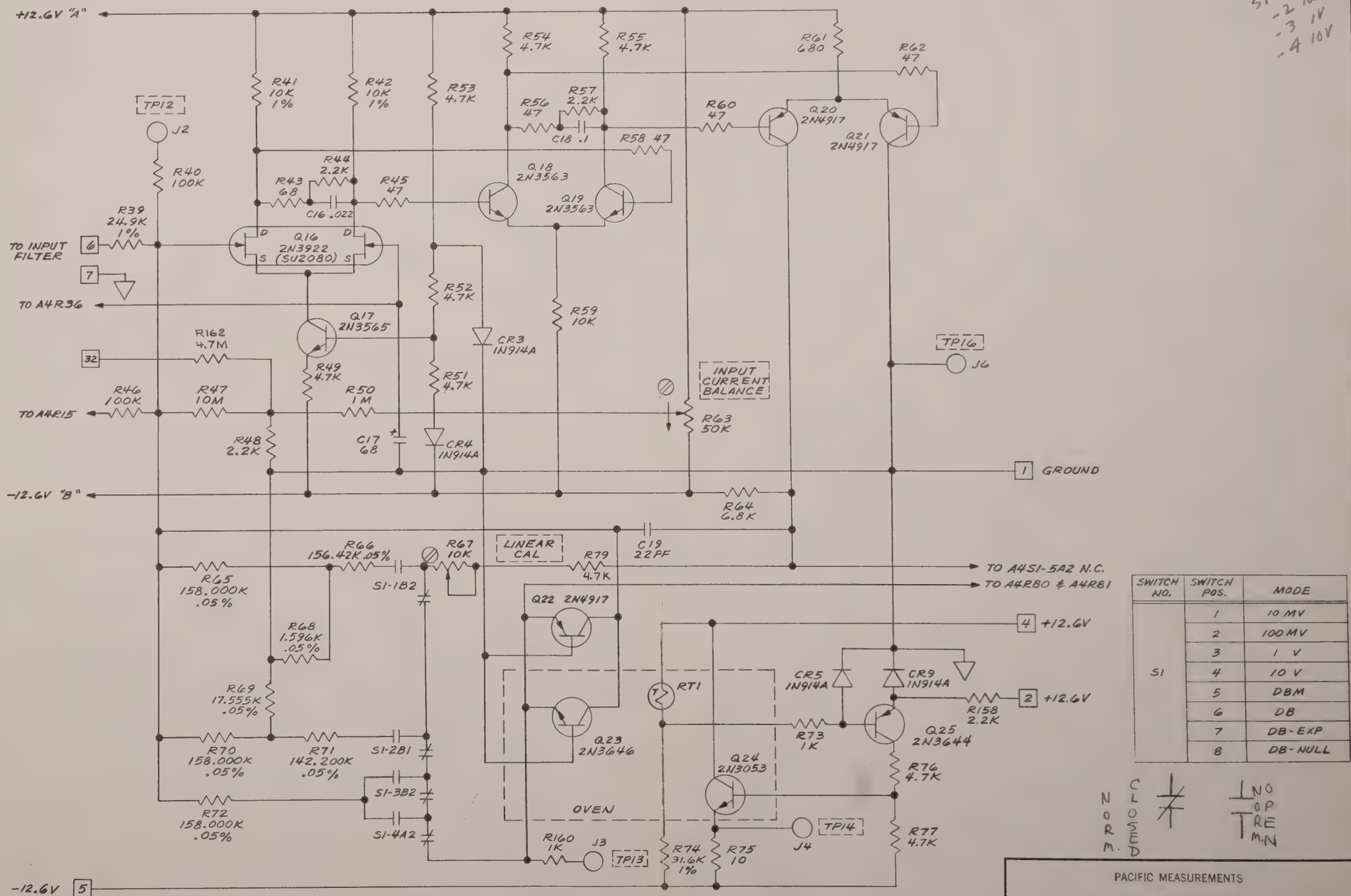


NOTES
UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% ¼ WATT. CAPACITOR VALUES ARE IN MICROFARADS.

PACIFIC MEASUREMENTS		
SCALE:	APPROVED BY:	DRAWN BY YO
DATE: 12-6-67		REVISED
INPUT CKT - CHOPPER AMP SECTION		
		DRAWING NUMBER 10868

SHT 1 OF 4

ASSEMBLY 10859
REFERENCE DESIGNATORS ARE ABBREVIATED
PREFIX WITH A4



S1-1 10mV
-2 100mV
-3 1V
-4 10V

SWITCH NO.	SWITCH POS.	MODE
S1	1	10 MV
	2	100 MV
	3	1 V
	4	10 V
	5	DBM
	6	DB
	7	DB-EXP
	8	DB-NULL

NORM. CLOSED

NO OP TERM.N

NOTE
UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% 1/4 WATT. CAPACITOR VALUES ARE IN MICROFARADS.

PACIFIC MEASUREMENTS

SCALE:	APPROVED BY:	DRAWN BY YO
DATE: 12-6-67	Ralph Britton	REVISED

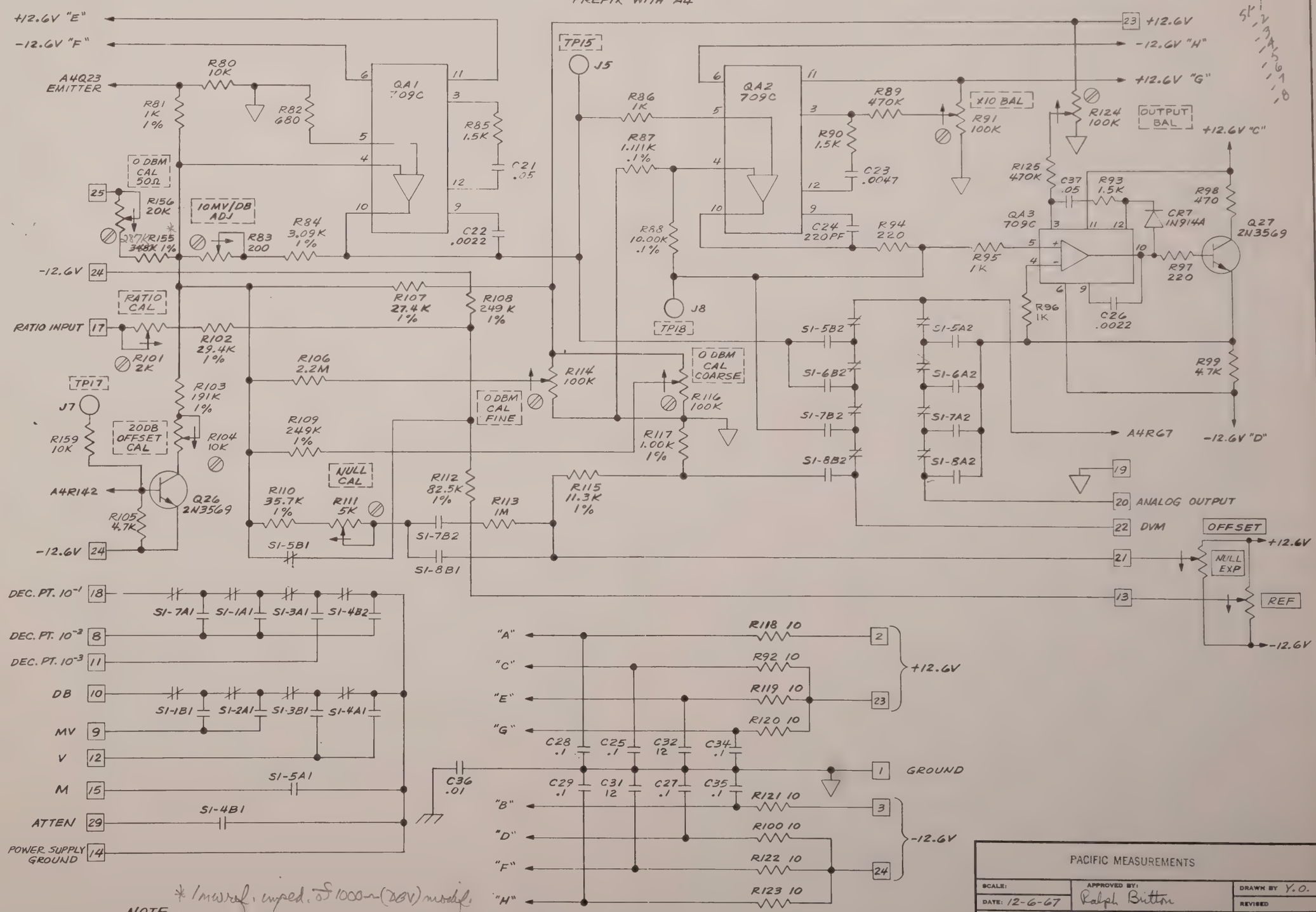
INPUT CKT - INPUT AMP SECTION

DRAWING NUMBER 10868

17X88 PRINTED ON NO. 1000M CLEARPRINT

A

ASSEMBLY 10859
REFERENCE DESIGNATORS ARE ABBREVIATED
PREFIX WITH A4



NOTE

* 1 meg ref. imped. of 1000Ω (20V) models.

UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% 1/4 WATT. CAPACITOR VALUES ARE IN MICROFARADS.

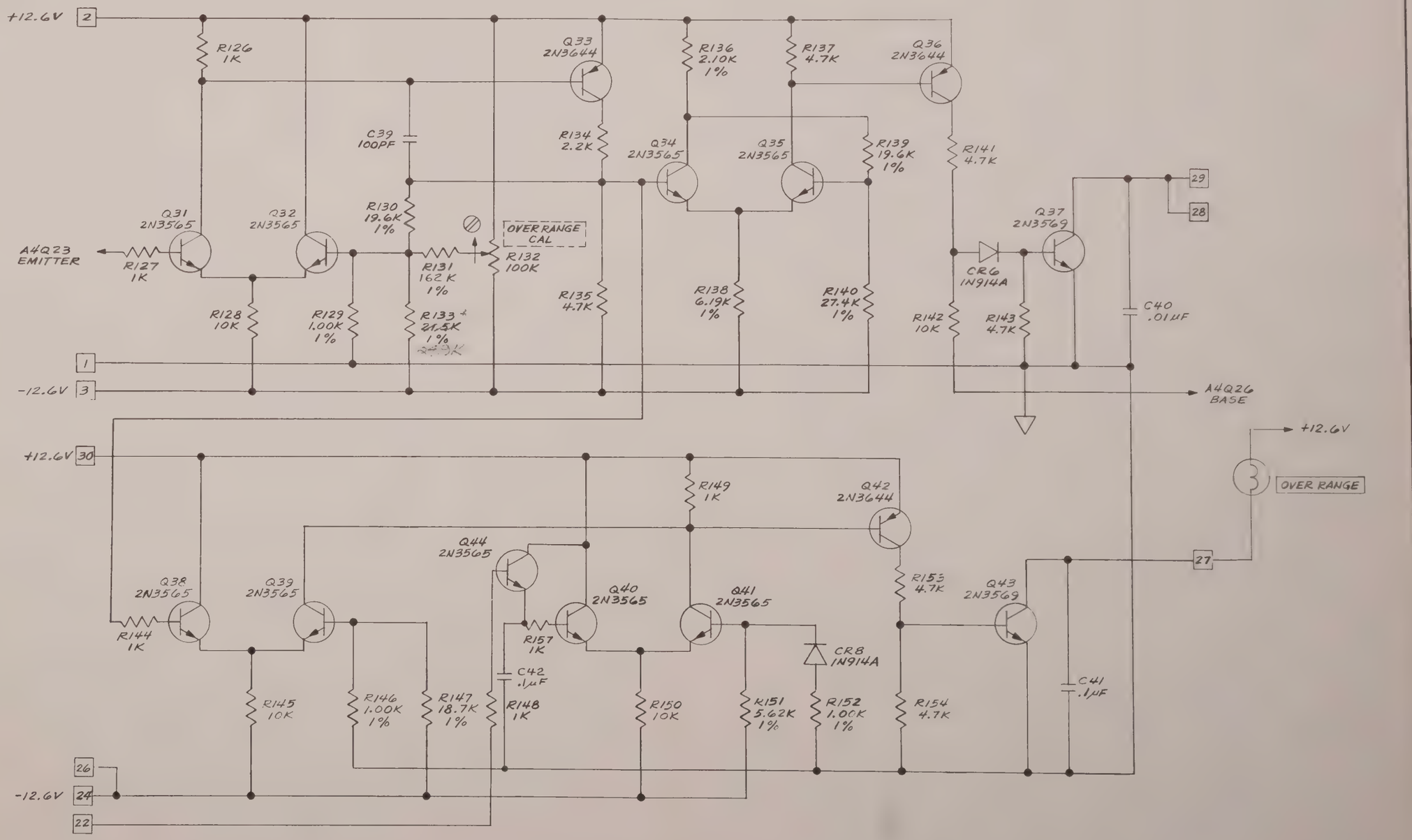
PACIFIC MEASUREMENTS

SCALE:	APPROVED BY: Ralph Britton	DRAWN BY Y.O.
DATE: 12-6-67		REVISED

INPUT CKT - OUTPUT AMP SECTION

DRAWING NUMBER 10868

ASSEMBLY 10859
REFERENCE DESIGNATORS ARE ABBREVIATED
PREFIX WITH A4



NOTE
UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE ±5% ¼ WATT.

* section 10 manual correction

PACIFIC MEASUREMENTS

SCALE:	APPROVED BY: Ralph Britton	DRAWN BY YO
DATE: 2-28-68		REVISED

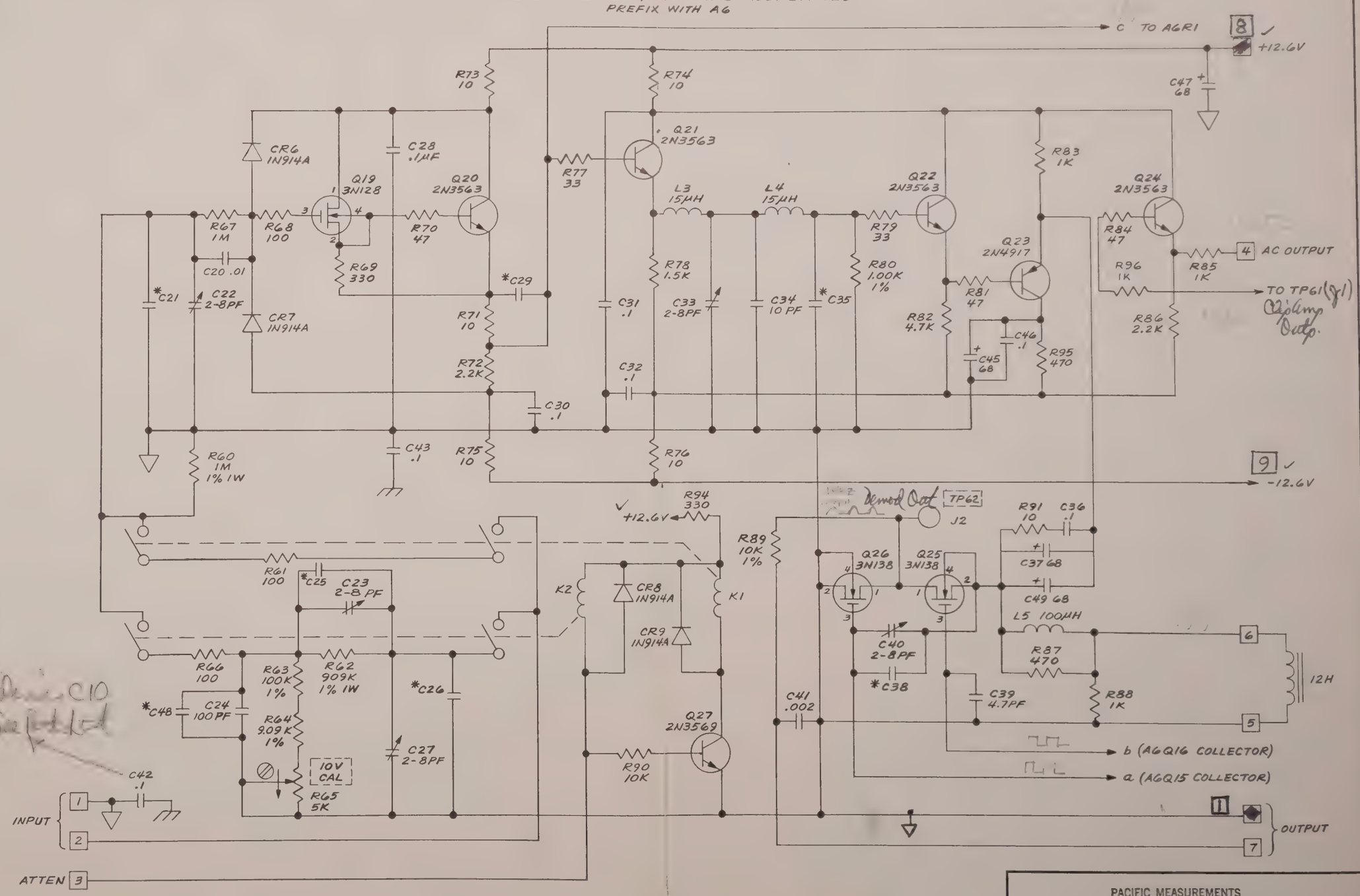
INPUT CKT AUTOMATIC SWITCHING AND OVER RANGE INDICATOR

DRAWING NUMBER 10863

SHT 4 OF 4

17X11 PRINTED ON NO. 1000H CLEARPRINT

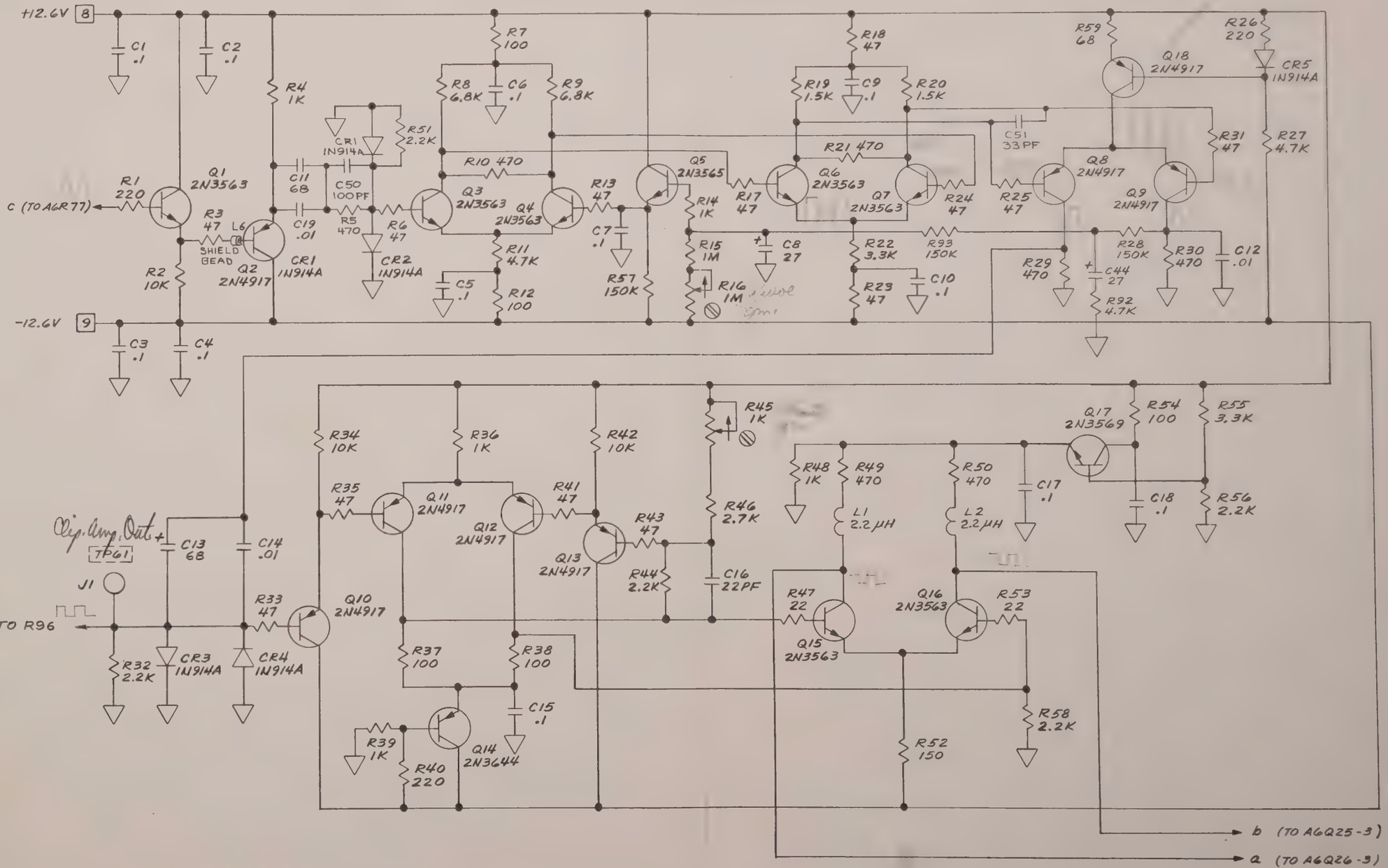
ASSEMBLY 10873
REFERENCE DESIGNATORS ARE ABBREVIATED
PREFIX WITH A6



NOTES
1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE ±5% ¼WATT. CAPACITOR VALUES ARE IN MICROFARADS.
2. * FACTORY SELECTED VALUES

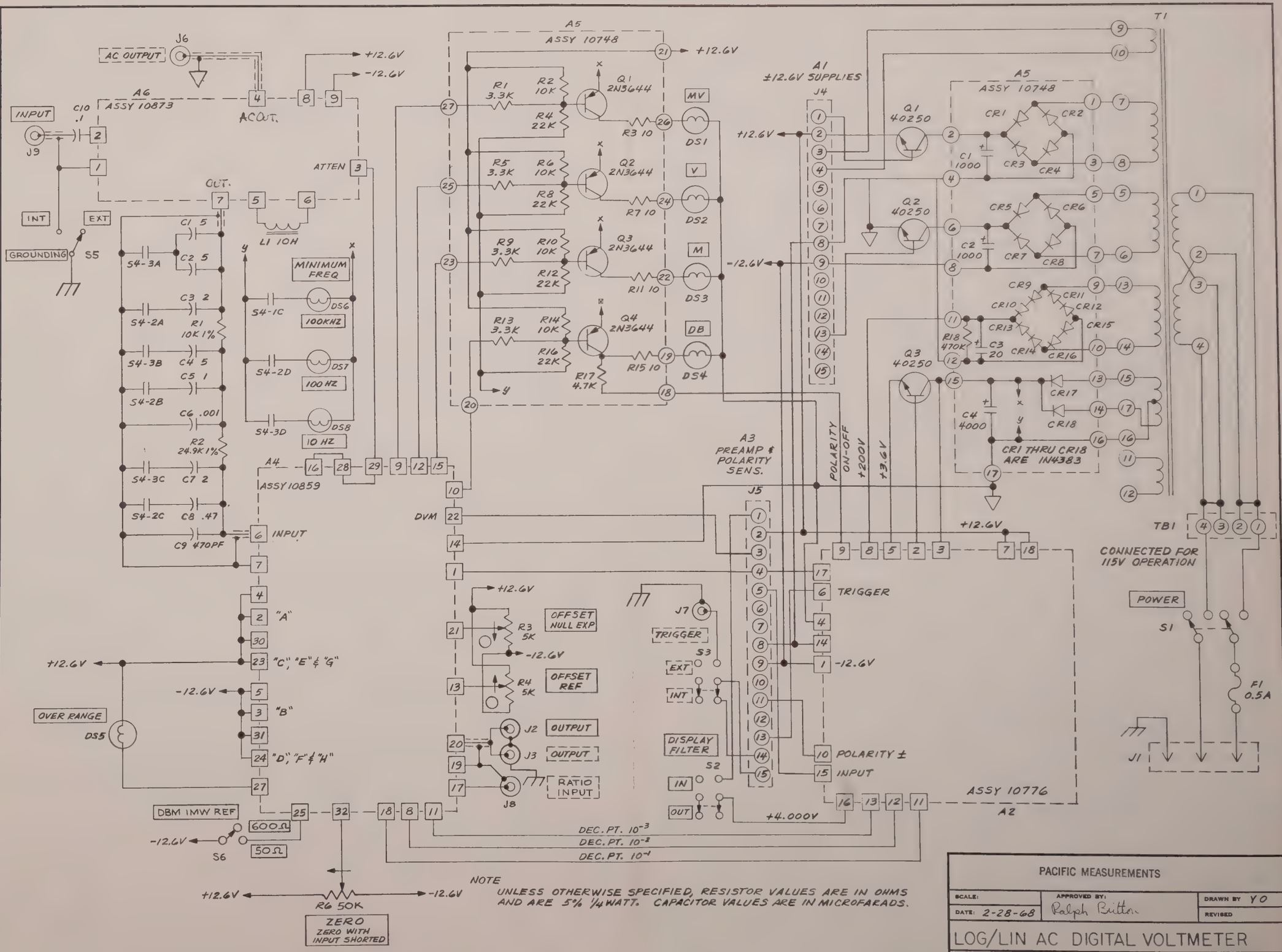
PACIFIC MEASUREMENTS		
SCALE:	APPROVED BY: Ralph Britton	DRAWN BY YO
DATE: 2-29-68		REVISED
AMPLIFIER MODULATOR		
		DRAWING NUMBER 10883

ASSEMBLY 10873
REFERENCE DESIGNATORS ARE ABBREVIATED
PREFIX WITH AG



NOTE:
UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% 1/4W. CAPACITOR VALUES ARE IN MICROFARADS.

PACIFIC MEASUREMENTS		
SCALE:	APPROVED BY: Ralph Britton	DRAWN BY YO
DATE: 12-21-67		REVISED
AMPLIFIER MODULATOR		DRAWING NUMBER 10883



NOTE

UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS AND ARE 5% 1/4 WATT. CAPACITOR VALUES ARE IN MICROFARADS.

PACIFIC MEASUREMENTS		
SCALE:	APPROVED BY: Ralph Britton	DRAWN BY YO
DATE: 2-28-68		REVISED
LOG/LIN AC DIGITAL VOLTMETER		
		DRAWING NUMBER 10931

17X22 PRINTED ON NO. 1000H CLEARPRINT

SECTION 9

REPLACEABLE PARTS LIST

CIRCUIT REFERENCE	PART NO.	DESCRIPTION
		CHASSIS - 10686
C1	10011-1	Mylar 5 µF ± 10% 200 V
C2	10011-1	Mylar 5 µF ± 10% 200 V
C3	10011-3	Mylar 2 µF ± 10% 200 V
C4	10011-1	Mylar 5 µF ± 10% 200 V
C5	10011-2	Mylar 1 µF ± 10% 200 V
C6	10000-4	Ceramic .001 µF ± 20% 1000 V
C7	10011-3	Mylar 2 µF ± 10% 200 V
C8	10011-4	Mylar .47 µF ± 10% 200 V
C9	10000-3	Ceramic 470 pF ± 20% 1000 V
C10	10637-1	Mylar 0.1 µ F ± 10% 600 V
DS1 MV	10712-1	Lamp 6V 40 mA
DS2 V	10712-1	Lamp 6V 40 mA
DS3 M	10712-1	Lamp 6V 40 mA
DS4 DB	10712-1	Lamp 6V 40 mA
DS5 OR	10060-3	Lamp Assembly 14V Red
DS6 (100's)	10712-1	Lamp 6V 40 mA
DS7 (10's)	10712-1	Lamp 6V 40 mA
DS8 (1's)	10712-1	Lamp 6V 40 mA
F1	10064-2	3AG 0.5A 250V
J1	10052	3 Pin AC Receptacle
J2	10048	BNC UG-1094/U
J3	10048	BNC UG-1094/U
J4	10050-1	Connector PC 15 Contacts
J5	10050-1	Connector PC 15 Contacts
J6	10048	BNC UG-1094/U
J7	10048	BNC UG-1094/U
J8	10048	BNC UG-1094/U
J9	10048	BNC UG-1094/U
L1	10635	10H
Q1	10020	40250
Q2	10020	40250
Q3	10020	40250
R1	10015-7	Metal Film 10.0 KΩ ± 1% 1/4 W
R2	10015-90	Metal Film 24.9 KΩ ± 1% 1/4 W
R3	10217	Variable 5 KΩ 10 Turn
R4	10217	Variable 5 KΩ 10 Turn
R5		Not Used
R6	10729-3	Variable 50 KΩ ± 30%
S1	10057	Toggle DPDT
S2	10059	Slide DPDT
S3	10059	Slide DPDT
S4	10906	Pushbutton 3 Position
S5	10059	Slide DPDT
S6	10059	Slide DPDT
T1	10791	Transformer
		POWER SUPPLY PC BOARD ASSEMBLY - 10121
A1C1	10787-4	Electrolytic 68 µF 15 WVDC
A1C2	10787-4	Electrolytic 68 µF 15 WVDC
A1C3	10000-7	Ceramic 0.01 µF ± 20% 500 VDC
A1C4	10000-7	Ceramic 0.01 µF ± 20% 500 VDC
A1C5	10000-7	Ceramic 0.01 µF ± 20% 200 VDC
A1C6	10000-7	Ceramic 0.01 µF ± 20% 200 VDC
A1C7	10787-4	Electrolytic 68 µF 15 WVDC
A1C8	10000-7	Ceramic 0.01 µF ± 20% 200 VDC
A1C9	10000-7	Ceramic 0.01 µF ± 20% 200 VDC
A1C10	10787-4	Electrolytic 68 µF 15 WVDC
A1C11	10000-7	Ceramic 0.01 µF ± 20% 200 VDC
A1C12	10787-4	Electrolytic 68 µF 15 WVDC
A1C13	10000-10	Ceramic 0.1 µF +80-20% 100 VDC
A1CR1	10044-1	1N4383
A1CR2	10045	1N823
A1J1	10054-2	Test PC Mounting, Red
A1J2	10054-1	Test PC Mounting, Black
A1J3	10054-3	Test PC Mounting, Blue
A1Q1	10017	2N3569
A1Q2	10019	2N3565
A1Q3	10019	2N3565
A1Q4	10017	2N3569
A1Q5	10019	2N3565
A1Q6	10019	2N3565
A1R1	10013-21	Carbon Film 470 Ω ± 5% 1/4 W
A1R2	10013-21	Carbon Film 470 Ω ± 5% 1/4 W
A1R3	10013-17	Carbon Film 220 Ω ± 5% 1/4 W
A1R4	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
A1R5	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
A1R6	10013-21	Carbon Film 470 Ω ± 5% 1/4 W
A1R7	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
A1R8	10015-1	Metal Film 1.54 KΩ ± 1% 1/4 W
A1R9	10046-9	Variable Comp. 100 Ω ± 20% Linear 1/4 W
A1R10	10015-1	Metal Film 1.54 KΩ ± 1% 1/4 W
A1R11	10013-17	Carbon Film 220 Ω ± 5% 1/4 W
A1R12	10013-33	Carbon Film 4.7 KΩ ± 5% 1/4 W
A1R13	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W
A1R14	10013-17	Carbon Film 220 Ω ± 5% 1/4 W
A1R15	10013-21	Carbon Film 470 Ω ± 5% 1/4 W
A1R16	10013-29	Carbon Film 2.2 KΩ ± 5% 1/4 W
A1R17	10015-1	Metal Film 1.54 KΩ ± 5% 1/4 W
A1R18	10046-6	Variable Comp. 200 Ω ± 20% Linear 1/4 W
A1R19	10015-1	Metal Film 1.54 KΩ ± 1% 1/4 W
A1R20	10013-13	Carbon Film 100 Ω ± 5% 1/4 W
		DIGITAL DISPLAY PC BOARD ASSEMBLY - 10776
A2C1	10000-10	Ceramic 0.1 µF -20 + 80% 100 V
A2C2	10001-12	Ceramic NPO 3.3 pF 5% 1000 V
A2C3	10001-3	Ceramic NPO 10 pF 5% 1000 V
A2C4	10000-10	Ceramic 0.1 µF -20 + 80% 100 V
A2C5	10000-10	Ceramic 0.1 µF -20 + 80% 100 V
A2C6	10787-4	Electrolytic 68 µF 15 V
A2C7	10000-10	Ceramic 0.1 µF -20 + 80% 100 V
A2C8	10787-4	Electrolytic 68 µF 15 V
A2C9	10000-2	Ceramic 220 pF ± 20% 1000 V
A2C10	10000-7	Ceramic 0.01 µF ± 20% 500 V
A2C11	10000-2	Ceramic 220 pF ± 20% 1000 V
A2C12	10585-3	Ceramic 470 pF ± 5% 1000 V

+5-28-82 Double Stuff C10 W/ Spare Cap Under Board. Put on Replacement Spacer

(A)

CIRCUIT REFERENCE	PART NO.	DESCRIPTION
A2C13	10000-3	Ceramic 470 pF ± 20% 1000 V
A2C14	10000-10	Ceramic 0.1 µF -20 + 80% 100 V
A2C15	10000-10	Ceramic 0.1 µF -20 + 80% 100 V
A2C16	10000-10	Ceramic 0.1 µF -20 + 80% 100 V
A2C17	10000-10	Ceramic 0.1 µF -20 + 80% 100 V
A2CR1	10043	1N914A
A2CR2	10043	1N914A
A2CR3	10043	1N914A
A2CR4	10043	1N914A
A2CR5	10043	1N914A
A2CR6	10043	1N914A
A2CR7	10043	1N914A
A2CR8	10045	1N823
A2CR9		Not Used
A2CR10	10043	1N914A
A2J1	10140-2	Test Jack, Yellow
A2J2	10140-2	Test Jack, Yellow
A2J3	10140-1	Test Jack, Red
A2J4	10140-1	Test Jack, Red
A2J5	10140-2	Test Jack, Yellow
A2J6	10140-2	Test Jack, Yellow
A2J7	10140-2	Test Jack, Yellow
A2Q1	10023	2N3644
A2Q2	10023	2N3644
A2Q3	10018	2N3646
A2Q4	10023	2N3644
A2Q5	10023	2N3644
A2Q6	10018	2N3646
A2Q7	10023	2N3644
A2Q8	10023	2N3644
A2Q9	10018	2N3646
A2Q10	10023	2N3644
A2Q11	10023	2N3644
A2Q12	10018	2N3646
A2Q13	10023	2N3644
A2Q14	10018	2N3646
A2Q15	10023	2N3644
A2Q16	10018	2N3646
A2Q17	10023	2N3644
A2Q18	10018	2N3646
A2Q19	10023	2N3644
A2Q20	10018	2N3646
A2Q21	10022	2N3640
A2Q22	10018	2N3646
A2Q23	10022	2N3640
A2Q24	10018	2N3646
A2Q25	10022	2N3640
A2Q26	10018	2N3646
A2Q27	10022	2N3640
A2Q28	10018	2N3646
A2Q29	10022	2N3640
A2Q30	10018	2N3646
A2Q31	10017	2N3569
A2Q32	10019	2N3565
A2Q33	10312	NS7302
A2Q34	10022	2N3640
A2Q35	10022	2N3640
A2Q36	10017	2N3569
A2Q37	10018	2N3646
A2Q38	10018	2N3646
A2Q39	10018	2N3646
A2Q40	10018	2N3646
A2Q41	10017	2N3569
A2Q42	10019	2N3565
A2Q43	10019	2N3565
A2Q44	10023	2N3644
A2Q45	10786	2N5184/2N4390
A2Q46	10786	2N5184/2N4390
A2Q47	10786	2N5184/2N4390
A2QA1	10722-3	Motorola MC 788p (Dual Buffer)
A2QA2	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA3	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA4	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA5	10722-6	Motorola MC 792p (Triple 3 Input Gate)
A2QA6	10722-1	Motorola MC 724p (Quad 2 Input Gate)
A2QA7	10722-4	Motorola MC 789p (Hex Inverter)
A2QA8	10722-1	Motorola MC 724p (Quad 2 Input Gate)
A2QA9	10722-2	Motorola MC 725p (Dual 4 Input Gate)
A2QA10	10722-6	Motorola MC 792p (Triple 3 Input Gate)
A2QA11	10722-6	Motorola MC 792p (Triple 3 Input Gate)
A2QA12	10722-6	Motorola MC 792p (Triple 3 Input Gate)
A2QA13	10722-2	Motorola MC 725p (Dual 4 Input Gate)
A2QA14	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA15	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA16	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA17	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA18	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA19	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA20	10722-5	Motorola MC 790p (Dual J-K Flip-Flop)
A2QA21	10728	Fairchild µL 9960 (Decoder Driver)
A2QA22	10728	Fairchild µL 9960 (Decoder Driver)
A2QA23	10728	Fairchild µL 9960 (Decoder Driver)
A2QA24	10722-1	Motorola MC 724p (Quad 2 Input Gate)
A2QA25	10743	Motorola MC 1709cp (Op. Amplifier)
A2R1	10013-35	Carbon Film 6.8 KΩ ± 5% 1/4 W
A2R2	10013-49	Carbon Film 100 KΩ ± 5% 1/4 W
A2R3	10046-1	Variable Composition 22 MΩ ± 5% 1/4 W
A2R4	10013-17	Carbon Film 220 Ω ± 5% 1/4 W
A2R5	10142-4	Carbon Composition 22 MΩ ± 5% 1/4 W
A2R6	10013-53	Carbon Film 220 KΩ ± 5% 1/4 W
A2R7	10725-1	Precision Wirewound 4 KΩ ± .05% 1/8 W
A2R8	10725-1	Precision Wirewound 4 KΩ ± .05% 1/4 W
A2R9	10013-37	Carbon Film 10 KΩ ± 5% 1/4 W

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
A2R10	10015-57	Metal Film 8.66 KΩ± 1% 1/4 W
A2R11	10013-45	Carbon Film 47 KΩ± 5% 1/4 W
A2R12	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R13	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R14	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R15	10725-2	Precision Wirewound 5 KΩ .05% 1/8 W
A2R16	10013-37	Carbon Film 10 KΩ± 5% 1/4 W
A2R17	10015-59	Metal Film 10.5 KΩ± 1% 1/4 W
A2R18	10013-45	Carbon Film 47 KΩ± 5% 1/4 W
A2R19	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R20	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R21	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R22	10726-1	Precision Wirewound 10 KΩ 0.1% 1/8 W
A2R23	10013-37	Carbon Film 10 kΩ± 5% 1/4 W
A2R24	10013-41	Carbon Film 22 KΩ± 5% 1/4 W
A2R25	10013-45	Carbon Film 47 KΩ± 5% 1/4 W
A2R26	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R27	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R28	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R29	10726-2	Precision Wirewound 20 KΩ± 0.1% 1/8 W
A2R30	10013-39	Carbon Film 10 KΩ± 5% 1/4 W
A2R31	10013-45	Carbon Film 47 KΩ± 5% 1/4 W
A2R32	10013-45	Carbon Film 47 KΩ± 5% 1/4 W
A2R33	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R34	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R35	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R36	10727-1	Precision Wirewound 40 KΩ 0.5% 1/8 W
A2R37	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R38	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R39	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R40	10727-2	Precision Wirewound 50 KΩ 0.5% 1/8 W
A2R41	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R42	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R43	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R44	10015-13	Metal Film 100 KΩ± 1% 1/4 W
A2R45	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R46	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R47	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R48	10015-62	Metal Film 200 KΩ± 1% 1/4 W
A2R49	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R50	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R51	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R52	10015-63	Metal Film 402 KΩ± 1% 1/4 W
A2R53	10013-49	Carbon Film 100 KΩ± 5% 1/4 W
A2R54	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R55	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R56	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R57	10015-45	Metal Film 499 KΩ± 1% 1/4 W
A2R58	10013-49	Carbon Film 100 KΩ± 5% 1/4 W
A2R59	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R60	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R61	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R62	10013-61	Carbon Film 1 MΩ± 5% 1/4 W
A2R63	10013-49	Carbon Film 100 KΩ± 5% 1/4 W
A2R64	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R65	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R66	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R67	10013-74	Carbon Film 2 MΩ± 5% 1/4 W
A2R68	10013-49	Carbon Film 100 KΩ± 5% 1/4 W
A2R69	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R70	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R71	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R72	10013-68	Carbon Film 3.9 MΩ± 5% 1/2 W
A2R73	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R74	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R75	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R76	10013-31	Carbon Film 3.3 KΩ± 5% 1/4 W
A2R77	10015-29	Metal Film 422 Ω± 1% 1/4 W
A2R78	10013-35	Carbon Film 6.8 KΩ± 5% 1/4 W
A2R79	10015-50	Metal Film 1.47 KΩ± 1% 1/4 W
A2R80	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R81	10015-70	Metal Film 681 Ω± 1% 1/4 W
A2R82	10015-69	Metal Film 196 Ω± 1% 1/4 W
A2R83	10015-68	Metal Film 100 Ω± 1% 1/4 W
A2R84	10015-3	Metal Film 49.9 Ω± 1% 1/4 W
A2R85	10015-71	Metal Film 909 Ω± 1% 1/4 W
A2R86	10013-11	Carbon Film 68 Ω± 5% 1/4 W
A2R87	10046-6	Variable Composition 200 Ω± 20% 1/4 W
A2R88	10015-72	Metal Film 1.96 KΩ± 1% 1/4 W
A2R89	10015-24	Metal Film 46.4 KΩ± 1% 1/4 W
A2R90	10015-24	Metal Film 46.4 KΩ± 1% 1/4 W
A2R91	10015-11	Metal Film 16.2 KΩ± 1% 1/4 W
A2R92	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R93	10013-29	Carbon Film 2.2 KΩ± 5% 1/4 W
A2R94	10013-39	Carbon Film 15 KΩ± 5% 1/4 W
A2R95	10013-25	Carbon Film 1 KΩ± 5% 1/4 W
A2R96	10013-23	Carbon Film 680 Ω± 5% 1/4 W
A2R97	10013-43	Carbon Film 33 KΩ± 5% 1/4 W
A2R98	10013-29	Carbon Film 2.2 KΩ± 5% 1/4 W
A2R99	10013-29	Carbon Film 2.2 KΩ± 5% 1/4 W
A2R100	10013-25	Carbon Film 1 KΩ± 5% 1/4 W
A2R101	10013-25	Carbon Film 1 KΩ± 5% 1/4 W
A2R102	10013-43	Carbon Film 33 KΩ± 5% 1/4 W
A2R103	10013-17	Carbon Film 220 Ω± 5% 1/4 W
A2R104	10013-17	Carbon Film 220 Ω± 5% 1/4 W
A2R105	10013-25	Carbon Film 1 KΩ± 5% 1/4 W
A2R106	10013-29	Carbon Film 2.2 KΩ± 5% 1/4 W
A2R107	10013-9	Carbon Film 47 Ω± 5% 1/4 W
A2R108	10013-33	Carbon Film 4.7 KΩ± 5% 1/4 W
A2R109	10013-29	Carbon Film 2.2 KΩ± 5% 1/4 W
A2R110	10013-37	Carbon Film 10 KΩ± 5% 1/4 W
A2R111	10013-29	Carbon Film 2.2 KΩ± 5% 1/4 W
A2R112	10013-37	Carbon Film 10 KΩ± 5% 1/4 W
A2R113	10013-13	Carbon Film 100 Ω± 5% 1/4 W
A2R114	10013-21	Carbon Film 470 Ω± 5% 1/4 W
A2R115	10013-45	Carbon Film 47 KΩ± 5% 1/4 W
A2R116	10013-41	Carbon Film 22 KΩ± 5% 1/4 W
A2R117	10013-25	Carbon Film 1 KΩ± 5% 1/4 W
A2R118	10013-37	Carbon Film 10 KΩ± 5% 1/4 W
A2R119	10013-41	Carbon Film 22 KΩ± 5% 1/4 W
A2R120	10013-37	Carbon Film 10 KΩ± 5% 1/4 W
A2R121	10013-41	Carbon Film 22 KΩ± 5% 1/4 W
A2R122	10013-37	Carbon Film 10 KΩ± 5% 1/4 W
A2R123	10013-41	Carbon Film 22 KΩ± 5% 1/4 W
A2R124	10013-1	Carbon Film 10 Ω± 5% 1/4 W
A2R125		Not Used
A2R126	10013-73	Carbon Film 10 MΩ ± 5% 1/4 W
A2R127	10142-2	Carbon Composition 15 MΩ± 5% 1/4 W
A2R128	10142-2	Carbon Composition 15 MΩ± 5% 1/4 W
A2R129	10142-2	Carbon Composition 15 MΩ ± 5% 1/4 W
A2R130	10013-33	Carbon Film 4.7 K ± 5% 1/4 W

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
		PREAMP, POLARITY & TRIGGER PC BOARD ASSEMBLY - 10760
A3C1	10000-10	Ceramic 0.1 µF +20 - 80% 100 VDC
A3C2	10787-4	Electrolytic 68 µF ± 20% 15 VDC
A3C3	10000-10	Ceramic 0.1 µF +20 - 80% 100 VDC
A3C4	10000-10	Ceramic 0.1 µF +20 - 80% 100 VDC
A3C5	10000-10	Ceramic 0.1 µF +20 - 80% 100 VDC
A3C6	10000-10	Ceramic 0.1 µF +20 - 80% 100 VDC
A3C7	10000-10	Ceramic 0.1 µF +20 - 80% 100 VDC
A3C8	10000-10	Ceramic .0047 µF ±20% 500 VDC
A3C9	10000-10	Ceramic 0.1 µF +20 - 80% 100 VDC
A3C10	10001-6	Ceramic NPO 47 pF ±5% 1000 V
A3C11	10787-3	Electrolytic 27 µF ±20% 15 VDC
A3C12	10000-6	Ceramic .0047 µF ±20% 500 VDC
A3C13	10000-2	Ceramic 220 pF ±20% 1000 VDC
A3C14	10000-6	Ceramic .0047 µF ±20% 500 VDC
A3C15	10000-2	Ceramic 220 pF ±20% 1000 VDC
A3C16	10000-10	Ceramic 0.1 µF +20 - 80% 100 V
A3C17	10000-7	Ceramic .01 µF ± 20% 500V
A3C18	10000-7	Ceramic .01 µF ± 20% 500 V
A3CR1	10761	1N279
A3CR2	10661	1N279
A3CR3	10043	1N914A
A3CR4	10043	1N914A
A3CR5	10043	1N914A
A3CR6	10043	1N914A
A3CR7	10043	1N914A
A3CR8	10043	1N914A
A3CR9	10043	1N914A
A3CR10	10043	1N914A
A3CR11	10043	1N914A
A3CR12	10043	1N914A
A3CR13	10043	1N914A
A3CR14	10043	1N914A
A3J1	10140-2	Test Jack, Yellow
A3Q1	10019	2N3565
A3Q2	10019	2N3565
A3Q3	10023	2N3644
A3Q4	10023	2N3644
A3Q5	10017	2N3569
A3QA1	10769	Motorola MC 1709cp (Op. Amplifier)
A3QA2	10769	Motorola MC 1709cp (Op. Amplifier)
A3QA3	10769	Motorola MC 1709cp (Op. Amplifier)
A3R1	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A3R2	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A3R3	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A3R4	10046-10	Variable Composition 100 KΩ ± 20% 1/4 W
A3R5	10013-57	Carbon Film 470 KΩ ±5% 1/4 W
A3R6	10013-27	Carbon Film 1.5 KΩ ±5% 1/4 W
A3R7	10726-5	Precision Wirewound 2.50 KΩ 0.1% 1/8 W
A3R8	10726-15	Precision Wirewound 7.50 KΩ ±0.1% 1/8 W
A3R9	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A3R10	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A3R11	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A3R12	10013-23	Carbon Film 680 Ω ±5% 1/4 W
A3R13	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A3R14	10013-31	Carbon Film 3.3KΩ ±5% 1/4 W
A3R15	10013-43	Carbon Film 33 KΩ ±5% 1/4 W
A3R16	10015-40	Metal Film 43.2 KΩ ±1% 1/4 W
A3R17	10015-25	Metal Film 61.9 KΩ ±1% 1/4 W
A3R18	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
A3R19	10013-45	Carbon Film 47 KΩ ±5% 1/4 W
A3R20	10046-10	Variable Composition 100 KΩ ±20% 1/4 W
A3R21	10013-57	Carbon Film 470 KΩ ±5% 1/4 W
A3R22	10013-27	Carbon Film 1.5 K ±5% 1/4 W
A3R23	10725-2	Precision Wirewound 5.00 KΩ ±0.05% 1/8W
A3R24	10725-2	Precision Wirewound 5.00 KΩ ±0.05% 1/8W
A3R25	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A3R26	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A3R27	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A3R28	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A3R29	10013-31	Carbon Film 3.3 KΩ ±5% 1/4 W
A3R30	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A3R31	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A3R32	10013-27	Carbon Film 1.5 KΩ ±5% 1/4 W
A3R33	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A3R34	10013-13	Carbon Film 100 Ω ±5% 1/4 W
		INPUT AMPLIFIER PC BOARD ASSEMBLY - 10859
A4C1	10007-7	Mylar 0.1 µF ±10% 200 VDC
A4C2	10001-5	Ceramic NPO 33 pF ±5% 1000 VDC
A4C3	10007-7	Mylar 0.1 µF ±10% 200 VDC
A4C4	10007-7	Mylar 0.1 µF ±10% 200 VDC
A4C5	10007-1	Mylar .001 µF ±10% 200 VDC
A4C6	10787-2	Tantalum 12 µF ±20% 15 VDC
A4C7	10000-1	Ceramic 100 pF ±20% 1000 VDC
A4C8	10787-2	Tantalum 12 µF ±20% 15 VDC
A4C9	10787-3	Tantalum 27 µF ±20% 15 VDC
A4C10	10787-2	Tantalum 12 µF ±20% 15 VDC
A4C11	10787-3	Tantalum 27 µF ±20% 15 VDC
A4C12	10000-8	Ceramic .022 µF ±20% 500 VDC
A4C13	10000-7	Ceramic .01 µF ±20% 500 VDC
A4C14	10007-5	Mylar .022 µF ±10% 200 VDC
A4C15	10787-4	Tantalum 68 µF ±20% 15 VDC
A4C16	10000-8	Ceramic .022 µF ±20% 500 VDC
A4C17	10787-4	Tantalum 68 µF ±20% 15 VDC
A4C18	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C19	10001-4	Ceramic NPO 22 pF ±5% 1000 VDC
A4C20		Not Used
A4C21	10000-9	Ceramic .05 µF +80 - 20% 500 VDC
A4C22	10000-5	Ceramic .0022 µF ±20% 500 VDC
A4C23	10000-6	Ceramic .0047 µF ±20% 500 VDC
A4C24	10000-2	Ceramic 220 pF ±20% 1000 VDC
A4C25	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C26	10000-5	Ceramic .0022 µF ±20% 1000 VDC
A4C27	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C28	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C29	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C30	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C31	10787-2	Tantalum 12 µF ± 20% 15 V
A4C32	10787-2	Tantalum 12 µF ± 20% 15 V
A4C33	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C34	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C35	10000-10	Ceramic 0.1 µF +80 - 20% 100 VDC
A4C36	10000-7	Ceramic .01 µF ±20% 500 VDC
A4C37	10000-9	Ceramic .05 µF +80 - 20% 500 VDC
A4C38		Not Used

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
A4C39	10000-1	Ceramic 100 pF ±20% 1000 VDC
A4C40	10000-7	Ceramic .01 μF ±20% 500 VDC
A4C41	10000-10	Ceramic 0.1 μF +80 - 20% 100 VDC
A4C42	10000-10	Ceramic 0.1 μF +80 - 20% 100 VDC
A4CR1	10043	1N914A
A4CR2	10043	1N914A
A4CR3	10043	1N914A
A4CR4	10043	1N914A
A4CR5	10043	1N914A
A4CR6	10043	1N914A
A4CR7	10043	1N914A
A4CR8	10043	1N914A
A4CR9	10043	1N914A
A4J1	10140-2	Test Jack, Yellow
A4J2	10140-2	Test Jack, Yellow
A4J3	10140-2	Test Jack, Yellow
A4J4	10140-2	Test Jack, Yellow
A4J5	10140-2	Test Jack, Yellow
A4J6	10140-2	Test Jack, Yellow
A4J7	10140-2	Test Jack, Yellow
A4J8	10140-2	Test Jack, Yellow
A4Q1	10018	2N3646
A4Q2	10023	2N3644
A4Q3	10023	2N3644
A4Q4	10019	2N3565
A4Q5	10019	2N3565
A4Q6	10018	2N3646
A4Q7	10896	3N138
A4Q8	10896	2N3644
A4Q9	10023	2N3644
A4Q10	10339	2N4360
A4Q11	10023	2N3644
A4Q12	10023	2N3644
A4Q13	10019	2N3565
A4Q14	10019	2N3565
A4Q15	10017	2N3569
* A4Q16	10207	2N3922 (SU2080)
A4Q17	10019	2N3565
A4Q18	10021	2N3563
A4Q19	10021	2N3563
A4Q20	10398	2N4917
A4Q21	10398	2N4917
A4Q22	10398	2N4917
A4Q23	10018	2N3646
A4Q24	10206	2N3053
A4Q25	10023	2N3644
A4Q26	10017	2N3569
A4Q27	10017	2N3569
A4Q28		Not Used
A4Q29		Not Used
A4Q30		Not Used
A4Q31	10019	2N3565
A4Q32	10019	2N3565
A4Q33	10023	2N3644
A4Q34	10019	2N3565
A4Q35	10019	2N3565
A4Q36	10023	2N3644
A4Q37	10017	2N3569
A4Q38	10019	2N3565
A4Q39	10019	2N3565
A4Q40	10019	2N3565
A4Q41	10019	2N3565
A4Q42	10023	2N3644
A4Q43	10017	2N3569
A4Q44	10019	2N3565
A4QA1	10743	Motorola MC 1709cp (Op. Amplifier)
A4QA2	10743	Motorola MC 1709cp (Op. Amplifier)
A4QA3	10743	Motorola MC 1709cp (Op. Amplifier)
A4R1	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A4R2	10013-47	Carbon Film 68 KΩ ±5% 1/4 W
A4R3	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
A4R4	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A4R5	10013-27	Carbon Film 1.5 KΩ ±5% 1/4 W
A4R6	10013-27	Carbon Film 1.5 KΩ ±5% 1/4 W
A4R7	10013-47	Carbon Film 68 KΩ ±5% 1/4 W
A4R8	10013-45	Carbon Film 47 KΩ ±5% 1/4 W
A4R9	10013-53	Carbon Film 220 KΩ ±5% 1/4 W
A4R10	10013-53	Carbon Film 220 KΩ ±5% 1/4 W
A4R11	10013-49	Carbon Film 100 KΩ ±5% 1/4 W
A4R12	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
A4R13	10013-39	Carbon Film 15 KΩ ±5% 1/4 W
A4R14	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A4R15	10013-49	Carbon Film 100 KΩ ±5% 1/4 W
A4R16	10013-1	Carbon Film 10 Ω ±5% 1/4 W
A4R17	10013-57	Carbon Film 470 KΩ ±5% 1/4 W
A4R18	10046-10	Variable Composition 100 KΩ ±20% 1/4 W
A4R19	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
A4R20	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A4R21	10013-45	Carbon Film 47 KΩ ±5% 1/4 W
A4R22	10013-73	Carbon Film 10 MΩ ±5% 1/4 W
A4R23	10013-19	Carbon Film 330 Ω ±5% 1/4 W
A4R24	10013-7	Carbon Film 33 Ω ±5% 1/4 W
A4R25	10013-19	Carbon Film 330 Ω ±5% 1/4 W
A4R26	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A4R27	10013-41	Carbon Film 22 KΩ ±5% 1/4 W
A4R28	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A4R29	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A4R30	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A4R31	10013-45	Carbon Film 47 KΩ ±5% 1/4 W
A4R32	10013-7	Carbon Film 33 Ω ±5% 1/4 W
A4R33	10013-21	Carbon Film 470 Ω ±5% 1/4 W
A4R34	10013-21	Carbon Film 470 Ω ±5% 1/4 W
A4R35	10013-37	Carbon Film 10 KΩ ±5% 1/4 W
A4R36	10013-57	Carbon Film 470 KΩ ±5% 1/4 W
A4R37	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A4R38	10013-25	Carbon Film 1 KΩ ±5% 1/4 W
A4R39	10015-90	Metal Film 24.9 KΩ ±1% 1/4 W
A4R40	10013-49	Carbon Film 100 KΩ ±5% 1/4 W
A4R41	10015-7	Metal Film 10 KΩ ±1% 1/4 W
A4R42	10015-7	Metal Film 10 KΩ ±1% 1/4 W
A4R43	10013-11	Carbon Film 68 Ω ±5% 1/4 W
A4R44	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A4R45	10013-9	Carbon Film 47 Ω ±5% 1/4 W
A4R46	10013-49	Carbon Film 100 KΩ ±5% 1/4 W
A4R47	10013-73	Carbon Film 10 MΩ ±5% 1/4 W
A4R48	10013-29	Carbon Film 2.2 KΩ ±5% 1/4 W
A4R49	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A4R50	10013-61	Carbon Film 1 MΩ ±5% 1/4 W
A4R51	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A4R52	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A4R53	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A4R54	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A4R55	10013-33	Carbon Film 4.7 KΩ ±5% 1/4 W
A4R56	10013-9	Carbon Film 47 Ω ±5% 1/4 W

* A4Q16 see note in other back manual for ordering replacement

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
A4R57	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A4R58	10013-9	Carbon Film 47 Ω±5% 1/4 W
A4R59	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A4R60	10013-9	Carbon Film 47 Ω±5% 1/4 W
A4R61	10013-23	Carbon Film 680 Ω±5% 1/4 W
A4R62	10013-9	Carbon Film 47 Ω±5% 1/4 W
A4R63	10046-3	Variable Composition 50 KΩ±20% 1/4 W
A4R64	10013-35	Carbon Film 6.8 KΩ±5% 1/4 W
A4R65	10725-7	Precision Wirewound 158.000 KΩ ±.05% 1/8 W
A4R66	10725-6	Precision Wirewound 156.420 KΩ ±.05% 1/8 W
A4R67	10046-8	Variable Composition 10 KΩ±20% 1/4 W
A4R68	10725-3	Precision Wirewound 1.596 KΩ±.05% 1/8 W
A4R69	10725-4	Precision Wirewound 17.555 KΩ ±.05% 1/8 W
A4R70	10725-7	Precision Wirewound 158.000 KΩ ±.05% 1/8 W
A4R71	10725-5	Precision Wirewound 142.200 KΩ ±.05% 1/8 W
A4R72	10725-7	Precision Wirewound 158.000 KΩ ±.05% 1/8 W
A4R73	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R74	10015-14	Metal Film 31.6 KΩ 1% 1/4 W
A4R75	10013-1	Carbon Film 10 Ω±5% 1/4 W
A4R76	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R77	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R78	10013-49	Carbon Film 100 KΩ±5% 1/4 W
A4R79	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R80	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A4R81	10015-19	Metal Film 1.00 KΩ±1% 1/4 W
A4R82	10013-23	Carbon Film 680 Ω±5% 1/4 W
A4R83	10046-6	Variable Composition 200 Ω±20% 1/4 W
A4R84	10015-110	Metal Film 3.01 KΩ±1% 1/4 W
A4R85	10013-27	Carbon Film 1.5 KΩ±5% 1/4 W
A4R86	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R87	10726-9	Precision Wirewound 1.111 KΩ .1% 1/8 W
A4R88	10726-1	Precision Wirewound 10.00 KΩ .1% 1/8 W
A4R89	10013-57	Carbon Film 470 KΩ±5% 1/4 W
A4R90	10013-27	Carbon Film 1.5 KΩ
A4R91	10046-10	Variable Composition 100 KΩ±20% 1/4 W
A4R92	10013-1	Carbon Film 10 Ω±5% 1/4 W
A4R93	10013-27	Carbon Film 1.5 KΩ±5% 1/4 W
A4R94	10013-17	Carbon Film 220 Ω±5% 1/4 W
A4R95	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R96	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R97	10013-17	Carbon Film 220 Ω±5% 1/4 W
A4R98	10013-21	Carbon Film 470 Ω±5% 1/4 W
A4R99	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R100	10013-33	Carbon Film 10 Ω±5% 1/4 W
A4R101	10046-5	Variable Composition 2 KΩ±20% 1/4 W
A4R102	10015-95	Metal Film 29.4 KΩ±1% 1/4 W
A4R103	10015-108	Metal Film 191 KΩ±1% 1/4 W
A4R104	10046-8	Variable Composition 10 KΩ±20% 1/4 W
A4R105	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R106	10013-65	Carbon Film 2.2 MΩ±5% 1/4 W
A4R107	10015-48	Metal Film 27.4 KΩ±1% 1/4 W
A4R108	10015-102	Metal Film 249 KΩ±1% 1/4 W
A4R109	10015-102	Metal Film 249 KΩ±1% 1/4 W
A4R110	10015-107	Metal Film 35.7 KΩ±1% 1/4 W
A4R111	10046-4	Variable Composition 5 KΩ±20% 1/4 W
A4R112	10015-33	Metal Film 82.5 KΩ±1% 1/4 W
A4R113	10013-61	Carbon Film 1 MΩ±5% 1/4 W
A4R114	10046-10	Variable Composition 100 KΩ±20% 1/4 W
A4R115	10015-81	Metal Film 11.3 KΩ±1% 1/4 W
A4R116	10046-10	Variable Composition 100 KΩ±20% 1/4 W
A4R117	10015-19	Metal Film 1.00 KΩ±1% 1/4 W
A4R118	10013-1	Carbon Film 10 Ω±5% 1/4 W
A4R119	10013-1	Carbon Film 10 Ω±5% 1/4 W
A4R120	10013-1	Carbon Film 10 Ω±5% 1/4 W
A4R121	10013-1	Carbon Film 10 Ω±5% 1/4 W
A4R122	10013-1	Carbon Film 10 Ω±5% 1/4 W
A4R123	10013-1	Carbon Film 10 Ω±5% 1/4 W
A4R124	10046-10	Variable Composition 100 KΩ±20% 1/4 W
A4R125	10013-57	Carbon Film 470 KΩ±5% 1/4 W
A4R126	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R127	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R128	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A4R129	10015-19	Metal Film 1.00 KΩ±1% 1/4 W
A4R130	10015-60	Metal Film 19.6 KΩ±1% 1/4 W
A4R131	10015-34	Metal Film 162 KΩ±1% 1/4 W
A4R132	10046-10	Variable Composition 100 KΩ±20% 1/4 W
A4R133	10015-[illegible]	Metal Film [illegible] KΩ±1% 1/4 W
A4R134	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A4R135	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R136	10015-84	Metal Film 2.10 KΩ±1% 1/4 W
A4R137	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R138	10015-105	Metal Film 6.19 KΩ±1% 1/4 W
A4R139	10015-60	Metal Film 19.6 KΩ±1% 1/4 W
A4R140	10015-48	Metal Film 27.4 KΩ±1% 1/4 W
A4R141	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R142	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A4R143	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R144	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R145	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A4R146	10015-19	Metal Film 1.00 KΩ±1% 1/4 W
A4R147	10015-16	Metal Film 18.7 KΩ±1% 1/4 W
A4R148	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R149	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R150	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A4R151	10015-104	Metal Film 5.62 KΩ±1% 1/4 W
A4R152	10015-19	Metal Film 1.00 KΩ±1% 1/4 W
A4R153	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R154	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A4R155	10015-[illegible]	Metal Film [illegible] KΩ±1% 1/4 W
A4R156	10046-2	Variable Composition 20 KΩ±20% 1/4 W
A4R157	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R158	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A4R159	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A4R160	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A4R161		Not Used
A4R162	10013-69	Carbon Film 4.7 MΩ±5% 1/4 W
A4RT1	10209	Thermistor 51R2
A4S1	10907	Switch, Pushbutton 8 Section

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
		RECTIFIER AND UNIT LIGHT DRIVER PC BOARD ASSEMBLY - 10748
A5C1	10003-2	Electrolytic 1000 µF 25 VDC
A5C2	10003-2	Electrolytic 1000 µF 25 VDC
A5C3	10003-4	Electrolytic 20 µF 300 VDC
A5C4	10003-3	Electrolytic 4000 µF 15 VDC
A5CR1	10044-1	1N4383
A5CR2	10044-1	1N4383
A5CR3	10044-1	1N4383
A5CR4	10044-1	1N4383
A5CR5	10044-1	1N4383
A5CR6	10044-1	1N4383
A5CR7	10044-1	1N4383
A5CR8	10044-1	1N4383
A5CR9	10044-1	1N4383
A5CR10	10044-1	1N4383
A5CR11	10044-1	1N4383
A5CR12	10044-1	1N4383
A5CR13	10044-1	1N4383
A5CR14	10044-1	1N4383
A5CR15	10044-1	1N4383
A5CR16	10044-1	1N4383
A5CR17	10044-1	1N4383
A5CR18	10044-1	1N4383
A5Q1	10023	2N3644
A5Q2	10023	2N3644
A5Q3	10023	2N3644
A5Q4	10023	2N3644
A5R1	10013-31	Carbon Film 3.3 KΩ±5% 1/4 W
A5R2	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A5R3	10013-1	Carbon Film 10 Ω±5% 1/4 W
A5R4	10013-41	Carbon Film 22 KΩ±5% 1/4 W
A5R5	10013-31	Carbon Film 3.3 KΩ±5% 1/4 W
A5R6	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A5R7	10013-1	Carbon Film 10 Ω±5% 1/4 W
A5R8	10013-41	Carbon Film 22 KΩ±5% 1/4 W
A5R9	10013-31	Carbon Film 3.3 KΩ±5% 1/4 W
A5R10	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A5R11	10013-1	Carbon Film 10 Ω±5% 1/4 W
A5R12	10013-41	Carbon Film 22 KΩ±5% 1/4 W
A5R13	10013-31	Carbon Film 3.3 KΩ±5% 1/4 W
A5R14	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A5R15	10013-1	Carbon Film 10 Ω±5% 1/4 W
A5R16	10013-41	Carbon Film 22 KΩ±5% 1/4 W
A5R17	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A5R18	10013-57	Carbon Film 470 KΩ±5% 1/4 W
		AMPLIFIER MODULATOR PC BOARD ASSEMBLY - 10873
A6C1	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C2	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C3	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C4	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C5	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C6	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C7	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C8	10787-3	Electrolytic 27 µF 15 WVDC
A6C9	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C10	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C11	10787-4	Electrolytic 68 µF 15 WVDC
A6C12	10000-7	Ceramic .01 µF ±20% 500 V
A6C13	10787-4	Electrolytic 68 µF 15 WVDC
A6C14	10000-7	Ceramic .01 µF ±20% 500 V
A6C15	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C16	10001-4	Ceramic 22 pF ±5% 1000 V
A6C17	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C18	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C19	10000-7	Ceramic .01 µF ±20% 500 V
A6C20	10000-7	Ceramic .01 µF ±20% 500 V
A6C21		Factory Selected
A6C22	10630-1	Variable Ceramic 2-8 pF NPO
A6C23	10630-1	Variable Ceramic 2-8 pF
A6C24	10001-7	Ceramic 100 pF ±5% NPO 1000 V
A6C25		Factory Selected
A6C26		Factory Selected
A6C27	10630-1	Variable Ceramic 2-8 pF NPO
A6C28	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C29		Factory Selected
A6C30	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C31	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C32	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C33	10630-1	Variable Ceramic 2-8 pF NPO
A6C34	10001-3	Ceramic 10 pF ±5% 1000 V NPO
A6C35		Factory Selected
A6C36	10000-10	Ceramic 0.1 µF ±20% 500 V
A6C37	10787-4	Electrolytic Tantalum 68 µF 15 VDC
A6C38		Factory Selected
A6C39	10001-2	Ceramic 4.7 pF ±5% 1000 V NPO
A6C40	10630-1	Variable Ceramic 2-8 pF NPO
A6C41	10585-6	Ceramic 2000 pF ±5% 1000 V
A6C42	10000-10	Ceramic 0.1 µF -20% +80% 100 V
A6C43	10000-10	Ceramic 0.1 µF -20% +80% 100 V
A6C44	10787-3	Electrolytic Tantalum 27 µF 15WVDC
A6C45	10787-4	Electrolytic Tantalum 68 µF 15WVDC
A6C46	10000-10	Ceramic 0.1 µF -20 +80% 100 V
A6C47	10787-4	Electrolytic Tantalum 68 µF 15WVDC
A6C48		Factory Selected
A6C49	10787-4	Electrolytic Tantalum 68 µF 15WVDC
A6C50	10000-1	Ceramic 100 pF ±20% 1000 V
A6C51	10001-5	Ceramic NPO 33 pF ±5% 1000 V
A6CR1	10043	1N914A
A6CR2	10043	1N914A
A6CR3	10043	1N914A
A6CR4	10043	1N914A
A6CR5	10043	1N914A
A6CR6	10043	1N914A
A6CR7	10043	1N914A
A6CR8	10043	1N914A
A6CR9	10043	1N914A
A6L1	10631-4	2.2 µH ±10%
A6L2	10631-4	2.2 µH ±10%
A6L3	10631-6	15 µH
A6L4	10631-6	15 µH
A6L5	10920-1	100 µH
A6L6	10182	Shield Bead

CIRCUIT REFERENCE	PM PART NO.	DESCRIPTION
A6K1	10966-2	Reed, 2 Form A 12 V
A6K2	10966-2	Reed, 2 Form A 12 V
A6J1	10140-2	Test Jack, Yellow
A6J2	10140-2	Test Jack, Yellow
A6Q1	10021	2N3565
A6Q2	10398	2N4917
A6Q3	10681	2N3563
A6Q4	10021	2N3563
A6Q5	10019	2N3565
A6Q6	10021	2N3563
A6Q7	10021	2N3563
A6Q8	10398	2N4917
A6Q9	10398	2N4917
A6Q10	10398	2N4917
A6Q11	10398	2N4917
A6Q12	10398	2N4917
A6Q13	10398	2N4917
A6Q14	10023	2N3644
A6Q15	10021	2N3563
A6Q16	10021	2N3563
A6Q17	10017	2N3569
A6Q18	10398	2N4917
A6Q19	10632	3N128
A6Q20	10021	2N3563
A6Q21	10021	2N3563
A6Q22	10021	2N3563
A6Q23	10398	2N4917
A6Q24	10021	2N3563
A6Q25	10896	3N138
A6Q26	10896	3N138
A6Q27	10017	2N3569
A6R1	10013-17	Carbon Film 220 Ω±5% 1/4 W
A6R2	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A6R3	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R4	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A6R5	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R6	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R7	10013-13	Carbon Film 100 Ω±5% 1/4 W
A6R8	10013-35	Carbon Film 6.8 KΩ±5% 1/4 W
A6R9	10013-35	Carbon Film 6.8 KΩ±5% 1/4 W
A6R10	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R11	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A6R12	10013-13	Carbon Film 100 Ω±5% 1/4 W
A6R13	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R14	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A6R15	10013-61	Carbon Film 1 MΩ±5% 1/4 W
A6R16	10046-13	Variable Comp. 1 MΩ±20% 1/4 W
A6R17	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R18	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R19	10013-27	Carbon Film 1.5 KΩ±5% 1/4 W
A6R20	10013-27	Carbon Film 1.5 KΩ±5% 1/4 W
A6R21	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R22	10013-31	Carbon Film 3.3 KΩ±5% 1/4 W
A6R23	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R24	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R25	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R26	10013-17	Carbon Film 220 Ω±5% 1/4 W
A6R27	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A6R28	10013-51	Carbon Film 150 KΩ±5% 1/4 W
A6R29	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R30	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R31	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R32	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A6R33	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R34	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A6R35	10013-9	Carbon Film 47 Ω ±5% 1/4 W
A6R36	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A6R37	10013-13	Carbon Film 100 Ω±5% 1/4 W
A6R38	10013-13	Carbon Film 100 Ω±5% 1/4 W
A6R39	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A6R40	10013-17	Carbon Film 220 Ω±5% 1/4 W
A6R41	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R42	10013-37	Carbon Film 10 KΩ±5% 1/4 W
A6R43	10013-9	Carbon Film 47Ω±5% 1/4 W
A6R44	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A6R45	10046-7	Variable Comp. 1 KΩ±20% 1/4 W
A6R46	10013-30	Carbon Film 2.7 KΩ±5% 1/4 W
A6R47	10013-5	Carbon Film 22 Ω±5% 1/4 W
A6R48	10013-25	Carbon Film 1 KΩ±5% 1/4 W
A6R49	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R50	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R51	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A6R52	10013-15	Carbon Film 150 Ω±5% 1/4 W
A6R53	10013-5	Carbon Film 22 Ω±5% 1/4 W
A6R54	10013-13	Carbon Film 100 Ω±5% 1/4 W
A6R55	10013-31	Carbon Film 3.3 KΩ±5% 1/4 W
A6R56	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A6R57	10013-51	Carbon Film 150 KΩ±5% 1/4 W
A6R58	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A6R59	10013-11	Carbon Film 68 Ω±5% 1/4 W
A6R60	10634-3	Metal Film 1 MΩ±1% 1 W
A6R61	10013-13	Carbon Film 100 Ω±5% 1/4 W
A6R62	10634-4	Metal Film 909 K ±1% 1 W
A6R63	10015-13	Metal Film 100 K ±1% 1/4 W
A6R64	10015-12	Metal Film 9.09 K ±1% 1/4 W
A6R65	10046-4	Variable Comp. 5 KΩ±20% 1/4 W
A6R66	10013-13	Carbon Film 100 Ω±5% 1/4 W
A6R67	10013-61	Carbon Film 1 M ±5% 1/4 W
A6R68	10013-13	Carbon Film 100 Ω±5% 1/4 W
A6R69	10013-19	Carbon Film 330 Ω±5% 1/4 W
A6R70	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R71	10013-1	Carbon Film 10 Ω±5% 1/4 W
A6R72	10013-29	Carbon Film 2.2 KΩ±5% 1/4 W
A6R73	10013-1	Carbon Film 10 Ω±5% 1/4 W
A6R74	10013-1	Carbon Film 10 Ω±5% 1/4 W
A6R75	10013-1	Carbon Film 10 Ω±5% 1/4 W
A6R76	10013-1	Carbon Film 10 Ω±5% 1/4 W
A6R77	10013-7	Carbon Film 33 Ω±5% 1/4 W
A6R78	10013-27	Carbon Film 1.5 K ±5% 1/4 W
A6R79	10013-7	Carbon Film 33 Ω±5% 1/4 W
A6R80	10015-19	Metal Film 1 K ±1% 1/4 W
A6R81	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R82	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A6R83	10013-25	Carbon Film 1 K ±5% 1/4 W
A6R84	10013-9	Carbon Film 47 Ω±5% 1/4 W
A6R85	10013-25	Carbon Film 1 K ±5% 1/4 W
A6R86	10013-29	Carbon Film 2.2 K ±5% 1/4 W
A6R87	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R88	10013-25	Carbon Film 1 K ±5% 1/4 W
A6R89	10015-7	Metal Film 10 K ±1% 1/4 W
A6R90	10013-37	Carbon Film 10 K ±5% 1/4 W
A6R91	10013-1	Carbon Film 10 Ω±5% 1/4 W
A6R92	10013-33	Carbon Film 4.7 KΩ±5% 1/4 W
A6R93	10013-51	Carbon Film 150 KΩ±5% 1/4 W
A6R94	10013-19	Carbon Film 330 Ω±5% 1/4 W
A6R95	10013-21	Carbon Film 470 Ω±5% 1/4 W
A6R96	10013-25	Carbon Film 1 KΩ± 5% 1/4 W

SECTION 10

MANUAL CORRECTIONS

This section lists the corrections that must be incorporated in this manual to make it correspond to a particular instrument.

The serial number of each instrument is prefixed by a code number. This code number is used to identify the applicable manual corrections for a particular instrument.

CODE NO.	CORRECTIONS	PM PART NO.	SECTION OF MANUAL AFFECTED
05	~~XXXXX~~ Paragraph 7.2.2d: Change 4.5 ± 1.0V to 5.0 ± 2.0V and change 50 mV to 200 mV	Noted: 5/10/71 R.W.	
	Paragraph 7.2.2e: Change +TP5 to -TP5 and change -TP2 to +TP2	Noted: 5/10/71 R.W.	
	Paragraph 7.3.2j: change TP61 to TP11	Noted: 5/10/71 R.W.	
06	Make Corrections listed for Code 05		
	A4R133 change from 21.5KΩ to 24.9KΩ	10015-90	8, 9 Noted: 5/10/71 R.W.